DSG, CVH, US HA 215 .A5

# AMERICAN JOURNAL OF ALTERNATIVE AGRICULTURE

*1990* *Volume 5, Number 3*

# Alternative Agriculture News

## A monthly newsletter available from Institute for Alternative Agriculture

This balanced and objective newsletter, with a sound track record of successful reporting, can help you keep track of national, state, and local action to support low-input, sustainable agricultural systems.

### *Alternative Agriculture News-*

- Covers legislative developments at all levels of government.
- Summarizes reports and action by national, State, and local alternative agriculture organizations.
- Announces alternative agriculture conferences, meetings, and field days.
- Lists positions open.
- Announces important books and research reports.
- Highlights new alternative agriculture research and education initiatives.

Noted for its succinct yet comprehensive coverage, **Alternative Agriculture News** reports on action by all alternative agriculture groups. It covers:

- Universities and government agencies.
- Non-profit organizations.
- Industry.
- Environmental and farm groups.
- Consumer organizations.
- Private/public sector cooperative efforts.

By reading **Alternative Agriculture News**, you will be well informed about all of the major developments and trends in alternative agriculture.

### Here's how to subscribe:

$15 Membership in Institute for Alternative Agriculture (includes monthly newsletter)

$20 Personal subscription to the American Journal of Alternative Agriculture (4 issues per volume)

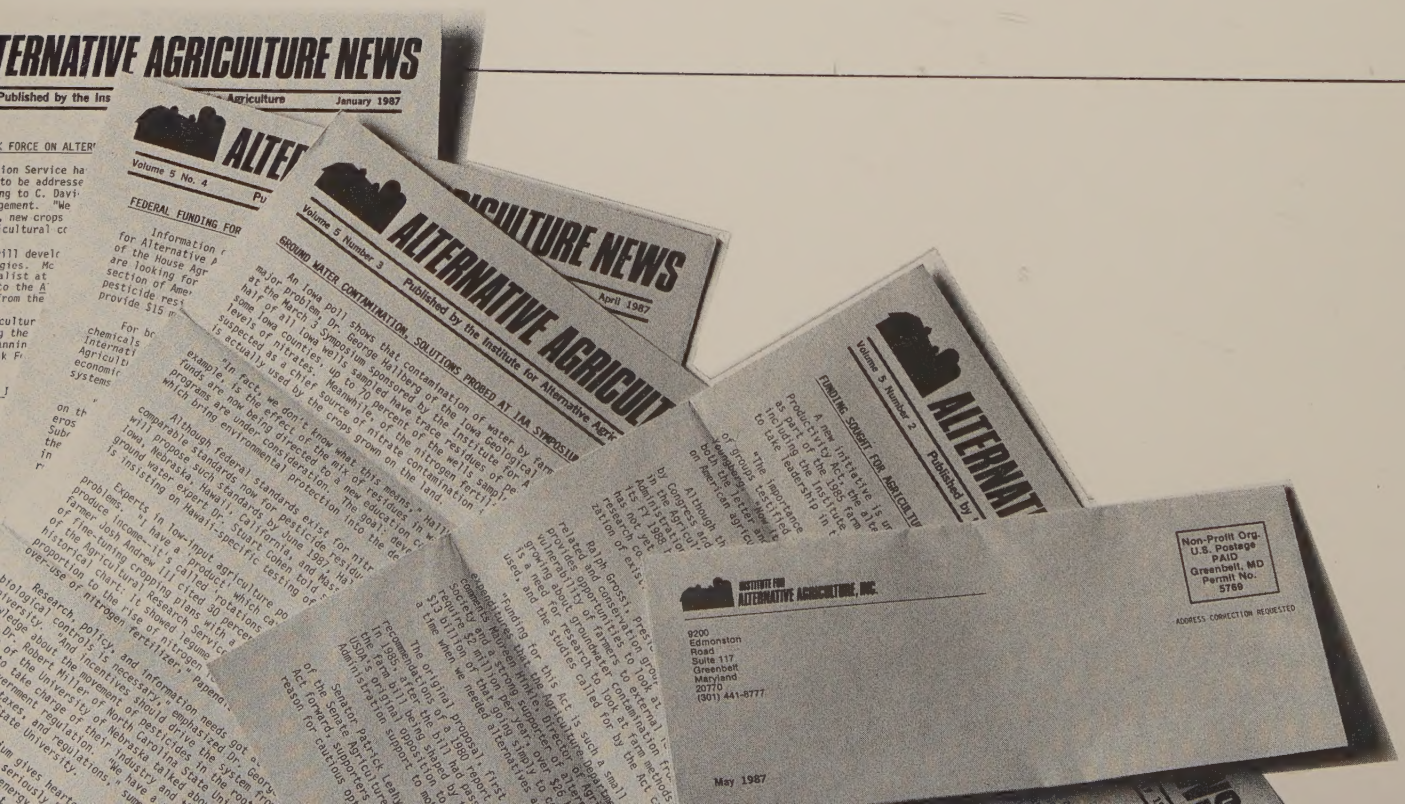
$30 Combination of IAA membership (including newsletter) and Journal subscription

$40 Institutional/organizational subscription to American Journal of Alternative Agriculture

- Student rates - Half off listed rates
- Foreign postage - Add $8/year for newsletter; add $7/year for Journal

INSTITUTE FOR ALTERNATIVE AGRICULTURE, INC.

9200 Edmonston Road, Suite 117
Greenbelt, Maryland 20770


ALTERNATIVE AGRICULTURE NEWS
Published by the Institute for Alternative Agriculture
January 1987
Volume 5 No. 4
FEDERAL FUNDING FOR
ALTERNATIVE AGRICULTURE NEWS
April 1987
Volume 6 Number 3
GROUND WATER CONTAMINATION SOLUTIONS PROBED AT IAA SYMPOSIUM
Published by the Institute for Alternative Agric
ALTERNATIVE AGRICULTURE NEWS
Volume 3 Number 2
FUNDING SOUGHT FOR AGRICULTU
INSTITUTE FOR ALTERNATIVE AGRICULTURE, INC.
9200 Edmonston Road Suite 117 Greenbelt Maryland 20770 (301) 441-8777
Non-Profit Org. U.S. Postage PAID Greenbelt, MD Permit No. 5760
ADDRESS CORRECTION REQUESTED
May 1987

AMERICAN JOURNAL OF
# ALTERNATIVE AGRICULTURE®

CAB INTERNATIONAL
Library Services Centre
28 SEP 1991

1990
Volume 5, Number 3

## TABLE OF CONTENTS

### Articles

**99** Farm program impacts on incentives for green manure rotations
*Douglas L. Young and Kathleen M. Painter*

**106** Organic viticulture in West Germany
*Stephen Dabbert and Jürgen Oberhofer*

**114** Mechanical and cultural weed control in corn and soybeans
*Jeffrey L. Gunsolus*

**120** Economic impacts of extended grazing systems
*G.E. D'Souza, E.W. Maxwell, W.B. Bryan, and E.C. Prigge*

**126** Ground water contamination from agricultural sources: Implications for voluntary policy adherence from Iowa and Virginia farmers' attitudes
*John M. Halstead, Steven Padgitt, and Sandra S. Batie*

**134** *Commentary:* Rotations: Influence and constraint from commodity programs
*Stephen Frerichs*

### Departments

Opinion—98 • Resources—133 • Institute News—138 • Book Reviews—139 • Letters—143 • Upcoming Events—144

*Journal Editorial Board*

Miguel A. Altieri, University of California at Berkeley • Lloyd A. Andres, USDA-ARS • David F. Bezdicek, Washington State University • Harold F. Breimyer, University of Missouri • Michael C. Brumm, University of Nebraska • Frederick H. Buttel, Cornell University • Katherine L. Clancy, Syracuse University • Eliot Coleman, Harborside, Maine • Kenneth A. Cook, Center for Resource Economics, Washington, DC • R. James Cook, USDA-ARS • John W. Doran, USDA-ARS • Sara Ebenreck, St. Mary's College • Thomas C. Edens, Michigan State University • Frank P. Eggert, University of Maine • Lloyd F. Elliot, USDA-ARS • A. Dale Flowerday, Pioneer Hi-Bred International • Charles A. Francis, University of Nebraska • Stephen R. Gliessman, University of California at Santa Cruz • Joan Gussow Columbia University • Don F. Hadwiger, Iowa State University • Richard R. Harwood, Michigan State University • Glenn A. Helmers, University of Nebraska • Larry D. King, North Carolina State University • Dietrich Knorr, University of Delaware • J. Patrick Madden, Madden Associates • Robert H. Miller, University of Rhode Island • Robert I. Papendick, USDA-ARS • James F. Parr, USDA-ARS/USAID • Richard L. Ridgway, USDA-ARS • Douglas L. Young, Washington State University.

*Institute Board of Directors*

Jerald R. DeWitt, Ames, IA; President • Mrs. Jean Wallace Douglas, Washington, DC; Honorary President • Maureen K. Hinkle, Washington, DC; Vice President • John A. Harris, IV, Berwyn, PA; Secretary • Jim Bender, Weeping Water, NE; Treasurer • David F. Bezdicek, Pullman, WA • Robert O. Blake, Washington, DC • Katherine L. Clancy, Syracuse, NY • Michael Heller, Upper Marlboro, MD • William C. Liebhardt, Davis, CA • Per Bye Ohrstrom, Arlington Heights, IL • Ward Sinclair, Warfordsburg, PA.

*Journal Staff*

Editor – *Garth Youngberg*
Technical Editor – *William Lockeretz*
Associate Technical Editors – *Paul B. Marsh*
– *Neill Schaller*
– *Marion E. Simpson*
Book Review Editors – *Thomas C. Edens*
– *James F. Parr*
Assistant to the Editor – *Sarah C. Byler*
Circulation Manager/Word Processing – *Susan E. Ward*
Art Director – *Randy White*

*Subscription Information*

The American Journal of Alternative Agriculture (ISSN 0889-1893) is published quarterly (winter, spring, summer, fall) by the Institute for Alternative Agriculture, Inc., 9200 Edmonston Road, Suite 117, Greenbelt, Maryland 20770. The IAA is not responsible for statements and opinions expressed by authors. Journal subscription rates: Institutions $40 a year ($47 foreign); Individuals $20 a year ($27 foreign); IAA Members $15 a year ($22 foreign); Students $10 a year ($17 foreign). Second Class postage paid at Greenbelt, MD. Postmaster: Send address changes to American Journal of Alternative Agriculture, 9200 Edmonston Road, Suite 117, Greenbelt, MD 20770.

*Institute Information*

The Institute for Alternative Agriculture is a nonprofit, tax-exempt research and education organization established in 1983 to encourage and facilitate the adoption of low-cost, resource-conserving and environmentally-sound farming methods. It works closely with producer groups, public research and education institutions, and government agencies in promoting a sustainable agriculture system.

Its programs include providing a national information clearinghouse, serving as a voice for sustainable agriculture in Washington, and developing and implementing research and educational outreach programs. It holds an annual scientific symposium and publishes a monthly newsletter.

The Institute is governed by a grass roots Board of Directors, which includes several commercial-scale organic farmers, and maintains a small professional staff. It is supported by memberships and donations and grants from foundations, corporations, and individuals.

*Cover Photo*

The cover photo shows an organic vineyard in early spring in Rheinpfalz near the city of Weyer, FRG. Green manuring is a standard organic viticulture practice in Germany. Photo provided by Mr. Bernd Ziegler, Official Research and Training Institute, Neustadt/Weinstrasse, FRG.

OPINION

# On the alleged convenience of chemical weed control in row crops in the Midwest

Jim Bender

Is chemical weed control in row crops more convenient than non-chemical weed control? Does it solve more problems or create fewer problems than the non-chemical alternative? Convenience is usually assumed to be the strong point of chemical weed control. I challenge this assumption. Here are some of the issues and problems of alternative systems of weed control in the context of a complete planting season. The force of my challenge will be the *sum* of considerations interspersed through four stages of a planting season.

**Early spring**

Machinery requirements are central to weed control decisions prior to the beginning of spring work. Non-chemical weed control (NCWC) requires none of the machinery associated with herbicide application. Chemical weed control (CWC) occasionally requires all the weed control machinery of NCWC. A rotary hoe and a row crop cultivator are minimally sufficient weed control machinery for NCWC. CWC requires some combination of the following spraying equipment: booms on tillage equipment, tanks on tractor(s), a general sprayer, and liquid handling equipment. In addition, almost all CWC systems include a row crop cultivator to manage uncertainties in chemical control and a rotary hoe to cope with crusting problems and herbicide failure. Whether the rotary hoe is owned, rented, or custom hired, it must be taken into account when planning a CWC system.

Another decision at this time of year concerns the location of crops. A CWC system is much more restrictive because of herbicide carryover. Issues include compatibility between this year's crop and last year's herbicide, living with herbicide-stressed crops when compatibility is misjudged, and sometimes being prevented from planting a particular crop in a field. One example is the incompatibility of oats with triazine herbicides. NCWC faces no such problems.

**Middle spring**

Primary concerns in spring tillage are weed control and seedbed preparation. CWC systems with pre-plant herbicides add the need for herbicide incorporation. The problem, from t perspective of convenience, is that herbicide incorporation ca not always be combined with another tillage operation. F example, operators sometimes till a field just to incorpora the herbicide and sometimes till a field twice to enhance t incorporation. Nothing is gained by extra tillage except incorp ration.

How much attention to detail in tillage do the alternati systems require? For NCWC the final tillage prior to planti must be thorough, both to control weeds and to enhance u form germination. Requirements of pre-plant herbicide incorp ration include completely uniform application. Missed spo result in no weed control. Overlaps increase herbicide costs a may increase herbicide stress on the crop. Uniform applicati also requires accurate tank mixes and correctly calibrat sprayer nozzles. CWC is more complicated and less convenie than NCWC at this stage of the planting season.

**Planting time**

Each method of weed control may place stress on the cro With NCWC the potential for stress is the rotary hoeing( which tears out some of the crop seedlings. For CWC the pote tial problem is herbicide stress. Only NCWC, however, perm compensatory measures. An operator can increase the planti rate to compensate for thinning by the rotary hoe. In contra CWC permits no way to compensate.

Planting places demands on a farmer's resources, and farmi at this time of year is complicated by CWC. Most chemi systems involve application of herbicides at some stage of pla ing, whether it is pre-plant incorporation by the tillage tract application with the planter unit, or pre-emergence applicatio In addition, the herbicide applicator who rigorously follo label and EPA instructions bears the burden of cumberso protective clothing and other measures. NCWC systems are f of all these concerns at this acutely busy time.

**Post planting**

Shortly after planting, the fine-tuned weed control of NCV systems must begin. The inherent advantage of this metho

Jim Bender is an organic farmer near Weeping Water, NE.

*Continued on page*

# Farm program impacts on incentives for green manure rotations

Douglas L. Young and Kathleen M. Painter

Abstract. *Farm programs influence the profitability of a crop rotation through five effects: (1) a deficiency payment (DP) effect, (2) an acreage reduction (ARP) effect, (3) a base effect, (4) a crop price effect, and (5) a risk reduction effect. This study initially examines ARP and DP effects of the 1985 Farm Bill on the relative profitability of a low-input rotation and a grain-intensive conventional rotation in Washington state over 1986-1990. In years of low deficiency payments or high foregone returns from ARP land, the low-input green manure rotation was competitive with the conventional rotation but lost its advantage in years of low ARP costs or high deficiency payments. Long-run incentives to maintain wheat base introduced a consistent bias against the low-input green manure rotation. Planting flexibility options proposed during the 1990 Farm Bill debate could reduce farm program barriers to green manure and other low-input rotations. The Bush Administration's Normal Crop Acreage (NCA) proposal, which was not accepted in the 1990 legislation, would have largely eliminated base erosion for the green manure rotation in this study. More importantly, non-ARP green manure acreage would have qualified for deficiency payments under the NCA, thereby sharply increasing the low-input rotation's relative profitability. Proposals like the NCA might receive further attention in the future due to environmental concerns, fiscal pressures, or possible trade agreements requiring multilateral phaseout of agricultural subsidies coupled to commodities.*

Key words: farm policy, sustainable agriculture, commodity programs, green manures, crop rotations

## Introduction

A major criticism of the 1985 Food Security Act (FSA), perhaps second only to its record cost to taxpayers, was its encouragement of inflexible cropping patterns dominated by the major program crops (House of Representatives, 1988; Ek, 1989a, 1989b; Office of the President, 1990). Because the major supported grain and row crops tend to be heavy users of agrichemicals (Osteen and Szmedra, 1989), farm programs have also been cited for discouraging low-input sustainable agriculture (National Research Council, 1989; Ek, 1989a). Growers were sometimes discouraged from using rotations that include green manure crops, hays, edible legumes, and other crops that conserve soil and reduce the use of pesticides because they reduced valuable base acreage of program crops. Before the 1990 Farm Bill debate, the Chairman of the House Agriculture Committee stated that Congress must consider "...the rigid and confining nature of the current crop-specific base system.... Flexibility should be a major objective of the next Farm Bill.... [The current base system] discourages the crop rotation methods that are the foundation of sound conservation practices" (de la Garza, 1989).

The 1990 Farm Bill permits growers the flexibility to plant 15 to 25 percent of their base acreage to program or specified other crops without losing future base acreage. Deficiency payments are not received on the grower's flexible base acreage, regardless of what is planted. In some rejected proposals, including the Administration's Normal Crop Acreage (NCA) plan, a grower's entire base acreage would have been flexible. In addition, deficiency payments would have been paid for program crops and unharvested conserving crops grown on flexible acres. Although the limited 15 to 25 percent base flexibility in the 1990 Bill fell short of initial expectations, it promises more flexibility than the 1985 legislation.

Despite the widespread view that the 1985 Farm Bill strongly discouraged cropping rotations, Dobbs et al. (1988) have called attention to a possible exception. Specifically, they demonstrate that the relative profitability of a low-input rotation in South Dakota that included an unharvested green manure was enhanced by the 1987 farm program. This soybean-wheat-oat-sweet clover rotation was slightly less profitable than a conventional soybean-wheat-oat rotation without the program but was 30 percent more profitable under 1987 program provisions. The low-input rotation's 25 percent unharvested sweet clover easily satisfied acreage reduction program (ARP) requirements. In the conventional rotation, 11 percent of the cropped area had to be left fallow as ARP. The green manure did double duty in the presence of farm programs: it reduced fertilizer and pesticide costs, and it satisfied ARP requirements. To assess the generality of this potential "program advantage" for rotations with unharvested green manure crops, we examine the influence of the 1985 FSA and the 1990

Douglas L. Young is Professor and Kathleen M. Painter is Research Assistant, Department of Agricultural Economics, Washington State University, Pullman, WA 99164.

NCA proposal on the profitability of a green manure and a conventional rotation over the period 1986-1990 in a southeastern Washington study area. We also provide a more comprehensive theoretical separation of the impacts that farm programs have on the profitability of alternative crop rotations. The analytical framework introduced here might prove useful in assessing impacts of future farm program modifications, such as those arising from possible deficit reduction agreements, environmental protection initiatives, or international trade treaties.

## Types of program effects

Theoretically, the influence of farm programs on the profitability of different crop rotations can be divided into five effects: (1) a deficiency payment (DP) effect, (2) an acreage reduction (ARP) effect, (3) a base effect, (4) a price effect, and (5) a risk reduction effect. The nonnegative DP effect per composite acre of rotation equals the sum of deficiency payments per acre for each crop, weighted by the proportion of acreage planted in each crop. The "composite acre of rotation" includes all crops, other land uses such as green manure or fallow, plus any required ARP land. The DP effect is proportional to the deficiency payment per bushel and to program yield because the payments are computed on a grower's historical or program yields. The DP effect is negatively correlated with the ARP rate because ARP land is excluded from deficiency payments.

The ARP effect per composite acre is composed of the weighted sum across program crops of the direct costs of maintaining each crop's ARP and the opportunity cost at market prices of foregoing net returns from production on each crop's ARP. The weights are the proportions of total rotational acreage in ARP for each crop.

The base effect measures the present value of expected changes in future program payments from changes in future base that result from this year's planting decisions. This effect can be either positive or negative; that is, planting decisions can either build or reduce the base. As an example, switching to a green manure rotation with less acreage in program crops could reduce future deficiency payments through shrinkage of base acreage.

The price effect measures changes in a rotation's profitability from changes in market prices brought about by farm programs. Programs could move prices in either direction, depending upon their effects on aggregate supply and demand. ARP's will reduce short-run aggregate supply, but incentives for long-run base building and other forms of slippage might increase aggregate supply. These supply effects will interact with aggregate demand to determine prices. Demand can also be altered by auxiliary programs like the FSA's Export Enhancement Program. Through substitution effects, farm programs can also influence prices of nonprogram crops. These program-induced price changes for program and nonprogram crops could either increase or decrease the relative profitability of low-input versus conventional rotations.

Finally, the risk reduction effect measures the value a risk averse decision maker assigns to any program-induced reduction in variability of net returns. Stabilizing farmers' incomes has been a major objective of commodity programs.

The possible "program advantage" for green manure rotations will depend on how program provisions affect green manure compared to conventional rotations. The inherent economic competitiveness of green manure versus conventional rotations in different parts of the country will also play an important role. Unlike previous studies that have considered only ARP or DP effects (Dobbs et al., 1988; Duffy, 1987; Goldstein and Young, 1987), the empirical analysis here will also address the base effect and will suggest possible approaches for considering the price and risk reduction effects.

## Background data: Palouse case study

In 1987, Goldstein and Young published an agronomic and economic comparison of a conventional rotation and an experimental green manure low-inp rotation for growing small grains in t eastern Palouse of Washington state. D spite its rudimentary economic analys of program effects, including explic omission of ARP costs, the study h been extensively cited as evidence of t economic bias of government progra against low-input rotations (e.g., N tional Research Council, 1989, pp. 23 239). Dobbs et al. (1988) later, more d tailed analysis showed favorable impac of farm programs on a particular gre manure rotation in South Dakota. The results indicate the need for more tho ough analysis of the Palouse case stud In this paper we extend that analysis include DP, ARP, and base effects wi the actual variations in market and pr gram variables over time.

Goldstein and Young's low-input r tation is a three-year sequence of pea winter wheat, and unharvested med green manure. The rotation is known PALS, an acronym for Perpetuating A ternative Legume System. Medic, a bie nial legume commonly used as a fora and cover crop in Australia and Europ fixes nitrogen and appears to retard ro diseases in wheat. It is seeded with pe in the first cycle, then perpetuates itse by natural reseeding. Reestablishment the medic stand is assumed to be r quired every nine years. Wheat, whic follows two years of legumes, is grow in PALS without commercial fertilize herbicides, or fungicides. In experime tal trials, wheat yields under PALS we similar to those in conventional rotatio with typical agrichemical applicatio (Goldstein and Young, 1987). Table summarizes yield and variable cost es mates for both PALS and the conve tional comparison. Unlike wheat, peas PALS required typical pesticide applic tions to control weeds and insects. Pe in PALS also yielded 10 percent less tha peas in the conventional rotation becau of competition from medic.

Goldstein and Young's four-year co ventional rotation, winter wheat-sprin barley-winter wheat-dry peas, include 75 percent government program cro compared to 33 percent for PALS. Th conventional rotation is relatively gra intensive for the region but would be re resentative of farms that have expande

wheat and barley bases in the past. Fertilizer, herbicide, and fungicide applications on conventional wheat reflect the increased fertility and pest control requirements of the intensive rotation. Total variable cost per rotational acre for PALS was $56.81, 44 percent as high as the $129.39 per acre cost of the conventional rotation (Table 1).

Table 2 reports market prices and program variables from 1986 through 1990. These years coincide with the 1985 FSA, thus providing a unified policy framework. This period offers the further advantage of large variations in market prices, deficiency payments, and ARP rates, thereby allowing an evaluation of whether the 1987 program advantage identified by Dobbs et al. (1988) persists under differing economic conditions. The endogenous adjustment of market prices and program variables over wide ranges (Table 2) underscores the importance of incorporating this joint variability when examining program effects on low-input rotations. A comparison of the profitability of conventional and low-input rotations for a single year, or a sensitivity analysis on just one variable as others are held constant, may fail to capture the full impact of the programs over time.

Table 3 reports acreage allocations for conventional and low-input (PALS) farmers with and without the FSA farm programs. The "with program" acreage allocations assume participation every year. This assumption reflects the high participation rate in the FSA wheat and barley programs during the study period. The conventional farm's initial wheat and barley bases are assumed to be strictly proportional to the representation of these crops in the conventional rotation, namely 50 and 25 percent, respectively. The conventional rotation completely uses available wheat and barley bases every year, thereby maintaining these bases at 50 and 25 percent. Because annual wheat and barley ARP rates change, the acreage planted to each crop varies over time rather than following a strict rotation (Table 3). Evidence from a recent survey of Palouse farmers indicates that maintaining base acreage often is dominant in farmers' planting decisions (Beus et al., 1990). Conventional farming permits easier alterations in actual crop proportions from year to year because increased or decreased fertility or pest control requirements can be accommodated by chemical applications.

Farmers using PALS are assumed to have "converted" from conventional histories, which means their inherited wheat and barley bases are 50 and 25 percent. Unlike their conventional neighbors who use more commercial fer-

Table 1. Crop Yields and Variable Costs for the Conventional and PALS Rotations.

| Crop/ Rotation | Yield[a] | 1986 Var. Costs ($/ac)[b] |
|---|---|---|
| Winter Wheat | —bu/ac— | |
| CONV | 80.00 | 145.53[c] |
| PALS | 80.00 | 47.46 |
| Spring Barley | —bu/ac— | |
| CONV | 83.34 | 101.58 |
| PALS | NA | NA |
| Dry Peas | —cwt/ac— | |
| CONV | 20.00 | 124.93 |
| PALS | 18.00 | 122.97[d] |
| Rotation | | |
| CONV | NA | 129.39 |
| PALS | NA | 56.81 |
| ARP | NA | 21.19 |

SOURCE: Goldstein and Young (1987)

[a] Goldstein and Young assumed equal yields for wheat in CONV and PALS based upon multi-year experimental trials. Yields were assumed constant over 1986–90 as they showed no discernible trend over this period.

[b] Costs for 1987–90 were inflated by the Index of Prices Paid by Farmers (1986 = 1.00) (USDA, 1989): 1.01 for 1987, 1.07 for 1988, 1.11 for 1989, and 1.15 for 1990 (est).

[c] The cost of winter wheat following ARP is $9.56/ac lower due to less preplanting tillage.

[d] Costs for PALS dry peas include the cost of medic seed once every nine years to renew the medic stand.

Table 2. Crop Prices and Program Variables, 1986–90.

| | Wheat ($/bu) | | | | | Barley ($/bu) | | | | | Peas ($/cwt) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Year | Mkt. Price | Target Price | Defic. Pmt. | Find. Pmt. | ARP (%) | Mkt. Price | Target Price | Defic. Pmt. | Find. Pmt. | ARP (%) | Mkt. Price |
| 1986 | 2.51 | 4.38 | 1.98 | .58 | 22.5 | 1.67 | 2.60 | .99 | .36 | 17.5 | 9.00 |
| 1987 | 2.82 | 4.38 | 1.81 | .28 | 27.5 | 1.87 | 2.60 | .79 | .05 | 20 | 7.60 |
| 1988 | 4.19 | 4.23 | .69 | 0 | 27.5 | 2.45 | 2.51 | 0 | 0 | 20 | 8.70 |
| 1989 | 4.05 | 4.10 | .32 | 0 | 10 | 2.30 | 2.43 | 0 | 0 | 10 | 8.10 |
| 1990 | 2.94* | 4.00 | 1.38* | 0 | 5 | 1.84* | 2.36 | .50* | 0 | 10 | 10.05* |

*Authors' projections.

SOURCES AND NOTES:

Market prices for 1986–89 are the Washington state marketing year averages as reported in Washington Department of Agriculture (1989). 1990 market prices for all crops are authors' projections based on August 1990 cash prices and futures quotations. Target prices and ARP rates for 1986–90 and deficiency payments for 1986–88 are from Harwood and Young (1989) and Ash and Hoffman (1989). Findly (Find.) supplemental deficiency payments were computed from data in the same two publications. Deficiency payments for 1989 are from ASCS, Colfax, WA and those for 1990 are authors' projections.

In the 1985 farm bill, deficiency payments nationwide equal the difference between the target price and the five-month *national* average market price (or loan rate if it is higher). Washington state average market prices generally exceed the national average because of transportation advantages. Averages for the entire marketing year can also differ from those for the first five months. These factors explain why the actual annual deficiency payments diverge from the difference between the listed target and (Washington state) market prices.

Table 3. Proportional Acreage Distribution by Rotation, Farm Program Available, and Year.

| Scenario | Year | Crop | | | | |
|---|---|---|---|---|---|---|
| | | Wheat | Barley | Peas | Unharv. Medic | ARP |
| Conventional with programs | 1986 | .388 | .206 | .250 | 0 | .156 |
| | 1987 | .363 | .200 | .250 | 0 | .188 |
| | 1988 | .363 | .200 | .250 | 0 | .188 |
| | 1989 | .450 | .225 | .250 | 0 | .075 |
| | 1990 | .475 | .225 | .250 | 0 | .050 |
| Conventional without programs | 1986–90 | .500 | .250 | .250 | 0 | 0 |
| PALS with or without programs | 1986–90 | .334 | 0 | .333 | .333 | 0[a] |

NOTE: Initial wheat and barley bases are 50 and 25 percent, respectively, of farm acreage.
[a] The unharvested medic meets ARP (set-aside) requirements for the PALS rotation.

tilizers and pesticides, low-input farmers participating in the farm program are assumed to maintain the PALS rotation strictly. The fixed two-to-one ratio of legumes to wheat is required for fertility and pest control, given the minimal use of pesticides and fertilizer. The inherited wheat base level is sufficient to permit the PALS rotation with program participation to continue during 1986-90, but, as will be discussed later, this rotational strictness can impose a cost in the long run.

## Analysis of FSA

Net returns over variable costs are computed in Table 4 for 1986-90 for the PALS and CONV rotations, both with and without farm programs. Several assumptions underlie these computations. First, only ARP and DP effects are considered at this stage. The average yields reported in Table 1 are used each year. This permits focusing on national program effects by excluding effects arising from local production variability. The average yields are also assumed to equal the producers' ASCS program yields. Returns to producers are the sum of crop sales at Washington state marketing year average prices listed in Table 2 and any applicable deficiency payments.

At this stage, the analysis ignores any market price effect that might result from the removal of the FSA in the "without programs" scenario. As in earlier studies (Duffy, 1987; Goldstein and Young, 1987; Dobbs et al., 1988), market prices are assumed to be identical whether or not a program is in effect. Following our quantitative analysis of ARP, DP, and base effects, we suggest an approach for relaxing this simplifying assumption when the necessary data are available.

As shown in Table 4, the net impact of the ARP and DP effects is mixed. In 1986, 1987, and 1990, the farm programs hurt the PALS rotation's relative profitability (PROFIT PALS/PROFIT CONV), but in 1988 and 1989 relative returns for PALS were boosted by t
FSA. For example, in 1988 the FS
boosted PALS' relative profitabili
from .83 to 1.08, but in 1986 the progra
reduced it from 1.25 to .92. Clearly, t
"program advantage" for green manu
rotations does not occur in gener
These results support Dobbs et al
(1988) observation that "...the form
[annual] program provisions and co
pliance requirements...will affect the r
ative competitiveness of low-input farm
ing systems."

To show why the FSA favored PAL
in some years but not others, Table
separates ARP and DP effects. The AR
effect is always negative for the conve
tional rotation because ARP occupi
land that otherwise would be planted
a profitable wheat or barley crop. Th
ARP effect is always zero for PALS b
cause the unharvested medic qualifies
ARP without any additional expens
ARP constitutes neither an opportuni
cost nor a direct cost for the PAL
farmer.

In 1986, 1987, and 1990, high DP e
fects dominate the net effect (Table 4
Because the conventional rotation has
higher proportion of land in progra
crops, it benefits more than PALS fro
the strong DP effect in those years. Fu

Table 4. Annual Net Returns, ARP Effects, and DP Effects ($/acre of rotation) for PALS and Conventio
Rotations due to 1985 Food Security Act (FSA).

| Year | Rotation & Ratio[a] | Net Returns Over Variable Costs | | DP Effect | ARP Effect | Ne Effe |
|---|---|---|---|---|---|---|
| | | No FSA | With FSA | | | |
| 1986 | PALS | 64 | 133 | 68 | 0 | 6 |
| | CONV | 51 | 144 | 103 | −10 | 9 |
| | *Ratio* | *1.25* | *.92* | | | |
| 1987 | PALS | 64 | 119 | 56 | 0 | 5 |
| | CONV | 59 | 119 | 75 | −16 | 5 |
| | *Ratio* | *1.08* | *1.00* | | | |
| 1988 | PALS | 103 | 122 | 18 | 0 | 1 |
| | CONV | 124 | 113 | 20 | −32 | −1 |
| | *Ratio* | *.83* | *1.08* | | | |
| 1989 | PALS | 94 | 102 | 8 | 0 | |
| | CONV | 107 | 108 | 12 | −11 | |
| | *Ratio* | *.88* | *.94* | | | |
| 1990 | PALS | 73 | 110 | 37 | 0 | 3 |
| | CONV | 57 | 116 | 62 | −2 | 6 |
| | *Ratio* | *1.28* | *.95* | | | |
| 1986–1990 Mean | PALS | 80 | 117 | 37 | 0 | 3 |
| | CONV | 80 | 120 | 54 | −14 | 4 |
| | *Ratio* | *1.00* | *.98* | | | |

[a] Ratio of net returns of PALS to the net returns of CONV for the year and program scenario.
[b] Because of rounding errors, net effect computed as the sum of the DP and ARP effect may differ sligh
from the same effect computed as the difference between With FSA returns and No FSA returns.

thermore, the negative ARP effect is small for the conventional rotation in these years; in 1986 and 1987 depressed market prices kept ARP opportunity costs low, and in 1990 the minimal 5 percent ARP had the same effect. Consequently, a combination of generous deficiency payments and modest ARP costs in 1986, 1987, and 1990 underlie the "program disadvantage" for PALS in those years. The FSA reduced the relative profitability ratio of PALS versus CONV in each of these years. In contrast, modest deficiency payments and larger ARP costs reduced the conventional rotation's program payoff in 1988 and 1989, which generated a relative "program advantage" for PALS in those years. In general, the relative profitability of green manure rotations like PALS will be favored by large ARP costs and lower deficiency payments.

Based solely on the ARP and DP effects in Table 4, the results are mixed as to whether a "with programs" or "without programs" world would be better for PALS. PALS had equal or slightly favorable profitability ratios of 1.00 and 1.08 in two years out of five with the FSA and stronger advantages of 1.25, 1.08, and 1.28 in three years out of five without it. Over the five years, PALS annual net returns averaged about 2 percent less than CONV for the "with programs" scenario (Table 4). In the "without programs" scenario, the five-year average annual net returns for the two rotations were identical.

The FSA strongly raised the absolute profitability of both rotations by an annual average of 46 percent for PALS and 50 percent for CONV. Participation in farm programs would have been profitable every year except 1988 for the conventional rotation. Based solely on the analysis in Table 4, which excluded market price effects, both low-input and conventional Palouse wheat growers would likely have suffered financial stress during 1986-90 without the FSA.

Table 5 considers the dynamic "base effect" of farm programs on the PALS grower. Consistent with ASCS procedures, entering base is computed as the average acreage planted and considered planted (in ARP) over the past five years. Before 1986, it is assumed that wheat and barley bases had been maintained at 50 and 25 percent for both the conventional and low-input farms. The base effect is zero for the conventional farm, which was assumed to plant and use as ARP its full wheat and barley bases every year during 1986-90, thereby experiencing neither declines nor increases in future bases.

On the other hand, a farmer who switched to the PALS rotation would have suffered substantial base losses under the provisions of the FSA. Because PALS contains no barley, barley base vanishes after five years. The loss of wheat base is even more serious because wheat is the key moneymaking crop in PALS. Years of tight supply-demand balance and low ARP's like 1989 and 1990 accelerate the loss of base under PALS because it receives little credit for the unharvested medic as "considered planted" ARP land.

Table 5. Wheat and Barley Annual History and Base Acreage for PALS Rotation Under Two Policy Scenarios.

| Item | Year | | | | | |
|---|---|---|---|---|---|---|
| | 1986 | 1987 | 1988 | 1989 | 1990 | 1991 |
| *FSA* | proportion of total acreage | | | | | |
| Wheat: | | | | | | |
| Entering Base | .50 | .49 | .48 | .47 | .44 | .41 |
| Annual History[a] | .43 | .46 | .46 | .37 | .35 | — |
| Barley: | | | | | | |
| Entering Base | .25 | .20 | .15 | .10 | .05 | 0 |
| Annual History[a] | 0 | 0 | 0 | 0 | 0 | — |
| *NCA Proposal* | | | | | | |
| Program Crops Plus Permitted Uses: | | | | | | |
| Entering Base | .75 | .73 | .72 | .70 | .69 | .67 |
| Annual History[a] | .67 | .67 | .67 | .67 | .67 | — |

[a] Planted and considered planted in current year.

Wheat base erosion can seriously endanger the long-term economic sustainability of PALS. As shown in Table 5, under a continuation of the base calculation provisions of the 1985 Farm Bill (FSA), the PALS farmer's wheat base falls from .50 in 1986 to .41 by 1991. If stocks continue to accumulate and push ARP's in the early 1990's up to 1986-88 levels, the PALS grower would need a wheat base of .43 to .46 (which would exceed the .41 available) in order to maintain the one-third wheat, one-third peas, one-third medic rotation. Under a continuation of this policy, the low-input grower would be faced with the choice of abandoning PALS as a fixed rotation or withdrawing from the profitable wheat program.

It is impossible to compute the exact present value of this shrinkage of wheat base (the "base effect") because future ARP's, target prices, and market prices are unknown. It is clear from Table 5, however, that the method of base calculation in the 1985 FSA reduces the long-run profitability of green manure rotations in the Palouse. In a recent survey, low-input Palouse farmers mentioned base loss more often and more stridently than any other policy as a barrier to rotations using green manures or grasses (Beus et al., 1990). Later we examine the potential for one base flexibility proposal to dismantle this "base barrier" to green manure rotations.

Estimating the "price effect" of the FSA would require a set of hypothetical free market crop prices over the 1986-90 study period. One way of obtaining such estimates is to derive them from a national agricultural sector model. If a satisfactory set of price estimates for this scenario were available, we could isolate the price effect by computing the "without programs" scenario in Table 4 both with these estimates and with observed "with program" prices from Table 2. The accuracy of these estimates would, of course, depend on the validity of the model from which they were derived. Various models of this type now in use tend to give widely different estimates.

A review of the historical experience of U.S. commodity programs indicates that their market price effects have been complex. Although a long-standing ob-

jective of the programs has been to control supply through ARP's and thereby increase market prices, the major program crops, including wheat, cotton, and feed grains, have been vulnerable to periodic surpluses that have depressed market prices. Clearly, the profit-enhancing and risk-reducing features of the programs appear occasionally to have increased supplies through base building and other forms of program slippage. During other periods, the programs appear to have been more effective in controlling supplies and raising prices of program crops. Consequently, it is difficult to generalize about the influence of price effects on the profitability of green manure rotations.

Although risk has not been considered in the analysis above, expected utility theory could be used to compare the risk-adjusted certainty equivalent of different cropping rotations and program scenarios. The change in the risk premium with the addition of farm programs would measure the "risk reduction effect" described earlier.

## NCA base flexibility proposal

The Administration's Normal Crop Acreage (NCA) proposal for the 1990 Farm Bill would have expanded base acreage flexibility to the whole farm and paid deficiency payments on flexible acres under certain conditions (Office of the President, 1990). Policies like the NCA might receive further attention in the future because of environmental or budgetary concerns or if the trade negotiations lead to a multilateral phaseout of agricultural subsidies coupled to specific commodities. Consequently, analysis of the NCA's impacts on economic incentives for the conventional and low-input rotations in this study should be useful.

The NCA proposal pools the grower's base acreage over all program crops and also permits green manures or other "conserving crops" to be counted for future base acreage calculations. If the conserving crop is not harvested, the grower receives deficiency payments. For example, if medic is planted on wheat base acreage, the farmer is eligible for wheat deficiency payments on the medic land. Alternatively, conserving crops like medic could continue to be used to satisfy ARP requirements.

We apply the NCA proposal to the PALS-conventional comparison retroactively, assuming it had been law during 1986-90 instead of the FSA. The last two lines in Table 5 show that the NCA proposal would have been markedly more effective than the FSA in sheltering the base acreage of a PALS farmer. By 1991, total base under the FSA would shrink to 41 percent of the farm, but under the NCA it would stabilize at 67 percent. With the NCA, the full 33 percent of acreage in green manure medic counts as "considered planted" every year, either as wheat ARP or as a conserving crop on the "flexible" NCA base. Accordingly, the NCA considered planted (Annual History) in Table 5 remains at 67 percent every year, composed of 34 percent wheat and 33 percent medic.

Table 6 reports estimated annual net returns over variable costs for the PALS and CONV rotations for both the 1985 FSA and the Administration's NCA proposal. Lacking program-specific estimates, we use the annual deficiency payments listed in Table 2 for both policies. A limitation of this approach is its failure to incorporate any differential price effects between the FSA and NCA, which could also have altered deficiency pa ments. The conventional rotation's n returns remain unchanged from Table because all NCA acreage is allocated wheat, barley, peas, and ARP exactly before, and market proceeds and de ciency payments are unchanged. Net r turns would increase every year fo PALS, however, because it now woul receive deficiency payments on no ARP medic acreage.

According to the analysis in Table based on historical prices, the PALS r tation would benefit substantially wit the NCA. Whereas PALS would lag b hind the conventional rotation in thr out of five years with the FSA, it woul earn more than CONV in all but on year under the NCA. Over the five-ye period, PALS averaged 2 percent less n returns than CONV with the FSA, a suming program participation. With th NCA, PALS returns averaged 11 pe cent higher than CONV. Although th estimates in Table 6 show that the NC increases the private competitiveness green manure rotations, the absolu profitability estimates should be inte preted cautiously. If the NCA had act ally been in effect during 1986-90, it likely that wheat acreage would ha been reduced more promptly, leading a quicker recovery of market whe prices. However, one result of high

Table 6. Net Returns and Difference in Deficiency Payments ($/acre of rotation) For Two Policies Rotation.

| Year | Rotation & Ratio[a] | Net Returns FSA | Net Returns NCA | Difference in D (NCA - FSA) |
|---|---|---|---|---|
| 1986 | PALS | 133 | 167 | 34 |
| | CONV | 144 | 144 | 0 |
| | *Ratio* | *.92* | *1.16* | |
| 1987 | PALS | 119 | 138 | 19 |
| | CONV | 119 | 119 | 0 |
| | *Ratio* | *1.00* | *1.16* | |
| 1988 | PALS | 122 | 123 | 1 |
| | CONV | 113 | 113 | 0 |
| | *Ratio* | *1.08* | *1.09* | |
| 1989 | PALS | 102 | 105 | 3 |
| | CONV | 108 | 108 | 0 |
| | *Ratio* | *.94* | *.97* | |
| 1990 | PALS | 110 | 134 | 24 |
| | CONV | 116 | 116 | 0 |
| | *Ratio* | *.95* | *1.16* | |
| 1986–1990 Mean | PALS | 117 | 133 | 16 |
| | CONV | 120 | 120 | 0 |
| | *Ratio* | *.98* | *1.11* | |

[a] Ratio of net returns, PALS/CONV, for the year and program scenario.

market prices could be an increase in wheat production by competing nations, which would tend to moderate those price increases. A higher market price for wheat, if realized, would have reduced deficiency payments, possibly producing results closer to those in the 1989 scenario in Table 6. For that year, returns for CONV were 6 percent higher than PALS under the FSA and 3 percent higher than PALS under the NCA.

The Integrated Farm Management (IFM) plan provision of the 1990 Farm Bill offers some of the same advantages to participating growers as the NCA proposal. Growers who sign three- to five-year renewable contractual plans to meet specified soil and water nondegradation standards will be granted base protection, subject to certain restrictions, on base acreage planted to green manure or selected other crops. Furthermore, deficiency payments will be paid on this acreage, net of ARP and the standard 15 percent unpaid flexible base. The plans also permit some haying and grazing on ARP land. It is unclear so far how popular the IFM plans will be with growers.

## Conclusions

Taking account of acreage reduction and deficiency payment effects, provisions of the 1985 FSA favored a low-input green manure (medic) rotation grown in southeastern Washington state in some years but penalized it in others. In years with lower deficiency payments or higher ARP costs, the case study green manure rotation became relatively more profitable. However, high deficiency payments coupled with modest ARP costs strongly favored the grain-intensive conventional rotation.

The mixed results for this study may apply only to other green manure rotations and not to fully harvested low-input rotations. Rotations that include low-input crops like hay rather than an unharvested green manure crop lose the option to use the low-input crop as ARP. These rotations are unlikely to be economically competitive with a conventional grain-intensive rotation under the government program provisions examined in this study. For example, Duffy (1987) reported monoculture corn in an Iowa study was 19 to 97 percent more profitable than four less intensive but fully harvested rotations, assuming government program participation. Without the FSA, all four rotations earned more than monoculture corn.

The incentive to maintain program crop base acreage levels to protect future government payments in the 1985 FSA represented a consistent program bias against the use of the green manure rotation in this analysis. Indeed, gradual loss of base could eventually force growers following this rotation out of the farm program.

This study's findings strongly support strengthening base flexibility in future farm policy legislation. It is crucial, however, that these proposals include soil building green manure crops in the list of specified alternative crops that can be grown on "flexible" base acres and on ARP acres, as in the Administration's 1990 NCA proposal. If it had been applied during 1986-90, NCA would have sheltered all the PALS green manure acreage as whole-farm base. Furthermore, the non-ARP green manure acreage would have qualified for deficiency payments under the NCA, thereby sharply increasing its profitability in comparison to the FSA and the conventional rotation.

This single region case study involving an experimental green manure rotation does not ensure widespread adoption of similar rotations with passage of the NCA or similar proposals. Such rotations may fail to be competitive in some regions because of physical or economic factors. Planting flexibility should also raise market prices of program crops and decrease prices of nonprogram crops, thereby improving the relative profitability of program crops. Nonetheless, these proposals represent an important step toward eliminating the penalties from farm programs for farmers considering adoption of more environmentally sound farming systems.

### References


1. Ash, M., and L. Hoffman. 1989. Barley: Background for 1990 farm legislation. ERS Staff Report No. 89-65, Economic Research Service, U.S. Department of Agriculture, Washington, DC.
2. Beus et al., eds. 1990. Prospects for sustainable agriculture in the Palouse: Farmer experiences and viewpoints. Research Bulletin XB1016, College of Agricultural & Home Economics, Washington State University, Pullman, Washington.
3. de la Garza, E. (Kika). 1989. A Democratic view: Making agricultural policy work--advice to the next president. Choices 3:16-19.
4. Dobbs, T. L., M. G. Leddy, and J. D. Smolik. 1988. Factors influencing the economic potential for alternative farming systems: Case analyses in South Dakota. Amer. J. of Alt. Ag. 3:26-34.
5. Duffy, M. 1987. Impacts of the 1985 Food Security Act. Department of Economics, Iowa State University, Ames, Iowa.
6. Ek, C. W. 1989a. Farm program flexibility: An analysis of the triple base option. Congress of the U.S., Congressional Budget Office, Washington, DC.
7. Ek, C. W. 1989b. The 1990 Farm Bill: Grains and oilseed issues. CRS Issue Brief., Environment and Natural Resources Policy Division, Congressional Research Service, The Library of Congress, Washington, DC.
8. Goldstein, W. A., and D. L. Young. 1987. An agronomic and economic comparison of a conventional and a low-input cropping system in the Palouse. Amer. J. of Alt. Ag. 2:51-56.
9. Harwood, J. L., and C. E. Young. 1989. Wheat: Background for 1990 farm legislation. ERS Staff Report No. AGES 89-56, Economic Research Service, U.S. Department of Agriculture, Washington, DC.
10. House of Representatives. 1988. Low-input farming systems: Benefits and barriers. 74th Report by the Committee on Government Operations. U.S. Government Printing Office, Washington, DC.
11. National Research Council. 1989. Alternative Agriculture. National Academy Press, Washington, DC.
12. Office of the President/USDA. 1990. Proposal of the Administration: 1990 Farm Bill. Washington, DC.
13. Osteen, C. D., and P. I. Szmedra. 1989. Agricultural pesticide use trends and policy issues. Agricultural Economics Report No. 622, Economic Research Service, U.S. Department of Agriculture, Washington, DC.
14. U.S. Department of Agriculture. 1989. Agricultural prices, December 29, 1989. National Agricultural Statistics Service, Washington, DC.
15. Washington Department of Agriculture. 1989. Washington agricultural statistics, 1988-1989. Washington Agricultural Statistics Service, Olympia, Washington.

# Organic viticulture in West Germany

Stephan Dabbert and Jürgen Oberhofer

Abstract. *We present results from a survey of organic grape operations in the three most important grape-producing areas in West Germany. Data on expenses for fertilizers,pesticides, machinery and buildings, on labor requirements, on the quantity and quality of yields, and on marketing channels and price premiums are compared to data on conventional grape operations from statistical sources. Based on these data, multi-period linear programming models were constructed to assess the economic implications of a transition to organic grape growing for different types of operations. Model results indicate that the grape production quota implemented in West Germany in 1989-90 favors organic methods. However, with direct marketing of wine, the effect of the quota depends on the effect that the expected rise in the price of conventional wine has on the price of organic wine. Premium prices for organically produced wine currently can be achieved only by farms that sell their wine directly to the consumer, which means that direct marketing is necessary for a profitable organic grape operation under current market conditions.*

Key words: Organic viticulture, economics, survey, linear programming, quota, direct marketing

## Introduction

The objective of the paper is to present an overview on the economics of organic grape production in West Germany, with special reference to the profitability of organic production as compared to conventional production under a new quota scheme. In Southwest Germany, viticulture is an important part of agriculture. In the state of Rheinland-Pfalz, for instance, 23 percent of gross value produced by the agricultural sector comes from viticulture (Statistics Department of Rheinland-Pfalz, 1989). Due to adverse climatic conditions, no table grapes are produced. However, because the taste of German wine has special characteristics, people are willing to pay a premium price. This premium is needed because production costs are higher than in many southern regions of the European community.

There is a growing interest in organic viticulture for three main reasons:

--As part of the development of the market for organic food, demand for organically grown wine is rising and premium prices are paid.

--Conventional wine production uses high inputs of pesticides and chemical fertilizers, so that ground water pollution by nitrates is a particularly serious problem in wine regions.

--Organic viticulture yields less wine per hectare, so that organic methods might be a way to achieve a reduction in the quantity of German wine produced. A reduction is necessary to comply with a quota scheme that was implemented in 1989-90.

The paper presents survey results from existing organic grape-growing operations in the three most important grape-growing regions in West Germany. Data from existing statistical sources are used to compare important characteristics of organic and conventional viticulture. In a second step, these data form a basis for economic models that assess the economic feasibility of organic compared with conventional viticulture under the conditions of the qu system implemented in West Germa in 1989-90.

## A definition of organic viticulture

Organic agriculture is generally fined in West Germany as producti according to certain production gui lines (Hamm, 1987; Dabbert, 1990). T minimum standards accepted by all ganic grower organizations in West G many are guidelines published by Stiftung Ökologischer Landbau (Fou dation for Organic Agriculture) in 19 For viticulture, four grower organi tions worked out guidelines that w published by the Stiftung Ökologisch Landbau in 1985. The four grower or nizations formed the Bundesverba Ökologischer Weinbau (Federal Asso ation for Organic Viticulture), wh currently is responsible for setting standards for organic viticulture. Gro ers may belong to just one of the f organizations, but most are also dir members of the Bundesverband Ökol ischer Weinbau. Growers' contra with one of the four grower organi tions regulate the standards and their forcement.

## The quota system

A production quota on the wine ind try already exists in West Germany, der which no new areas may be plan with grapes. This quota causes the pr of vineyard areas to be higher than th would otherwise be. Consequently, grape areas are diverted to other agric tural purposes. The basis for a new ad tional quota is that, with inelastic mand for German wine, prices will faster than production declines. Cor pondingly, the income of wine prod ers, which has been rather unsatisfact in recent years, will rise, with the c

Stephan Dabbert and Jürgen Oberhofer are Research and Teaching Associates with the Department of Agricultural Economics (410A), University of Hohenheim, Postfach 70 05 62, 7000 Stuttgart 70, West Germany.

sumer paying the bill. The means to achieve this is a quota that regulates the maximum quantity of wine that can be marketed from every hectare per year. The quota limits the quantity marketed per year, not the quantity produced. If harvest is higher than the quota in a certain year, the surplus may be stored, to be sold in a subsequent year when yield might be below the quota.

The quota is set by government authorities. It differs by region and, in some regions, by quality of wine produced. The quota is set on a per hectare basis. It does not differ for farms in the same region producing the same type of wine, which means that farmers that have had high yields in the past must cut down on production while farmers with low yields need not. In most regions, the average farmer will have to reduce production. The underlying assumption is reasonable, namely, that total demand for German wine is inelastic (that is, prices will rise relatively more than quantity declines), and, consequently, total sector income rises with a quota. However, elasticity might differ between regions and marketing channels.

## Methods

There are 11 grape-growing regions in West Germany. The regions differ greatly in growing conditions, such as type of soil, temperature, and slope. For historical reasons, they also differ in marketing channels. Out of these 11 regions, we selected 3 where most organic grape growers are found. These 3 regions, Rheinpfalz, Rheinhessen, and Baden, contain 82.4 percent of the total grape area and 64.2 percent of all organic vineyards in West Germany (Kiefer, 1986). Because the number of organic grape operations is still small, we attempted to collect data on every operation in these regions, using a list provided by the Bundesverband Ökologischer Weinbau. The list was supplemented by five farmers who are not direct members of the Bundesverband but belong only to one of the growers' organizations (Bioland).

Of 33 grape growers on the list, 30 were visited with a standardized questionnaire for a personal interview. Three refused to be interviewed. One questionnaire was not used because the operation was a hobby, not a commercial enterprise. Twenty-nine questionnaires were used to calculate the results presented below.

Multi-year economic models were constructed to assess the impact of the quota system on the profits of typical conventional wine operations. A second set of dynamic models embodies the assumption of wider use of organic methods. Differences between the two sets of forecasts can be used to estimate the relative profitability of organic production for typical farms.

To comply with the quota scheme, there are basically two ways for conventional operations to reduce the quantity produced per hectare: they can use their vineyards for a longer period, because yields decline with the age of the vines; or they can reduce the amount of fertilizers used.

These adjustment possibilities were incorporated into the conventional baseline models. Figure 1 presents yield in conventional production as a function of the age of the vineyard at three different levels of fertilization. It is an idealized version of what was found in experimental plots (Oberhofer, 1989).

For a dynamic model, it is necessary to make assumptions about changes in exogenous factors like prices, yields, and input costs. The following assumptions were derived using statistical methods and expert opinions:

--Labor requirements will be reduced by further technical progress at a rate of 0.5 percent per year.

--Yields in conventional and organic grape production will rise at a rate of 1.75 percent per year.

--Variable costs will rise 2.4 percent per year.

--Fixed costs will rise 3.87 percent per year.

--Prices for both conventional and organic wine will rise by 2.22 percent per year if the quantity produced does not change. However, if the quantity changes under the quota scheme, price increases will deviate from this rate according to the elasticity of demand.

Three different marketing approaches are common in West Germany:

--Grapes sold to a cooperative that processes them;

--Processing of the wine on the farm, to be sold by the barrel;

--Processing and bottling of the wine on the farm, to be sold directly to the consumer.

To investigate the consequences of the new quota, it is necessary to know for each of the three markets how prices change if quantity changes. For direct marketing, it was assumed that the following function holds for every region:

$q = f(I, p_1, p_2, p_3)$

where

$q$ = demand for wine from the region

$I$ = real income of consumers

$p_1$ = real price of wine from the region

$p_2$ = real price of wine from all other German regions

$p_3$ = real price of foreign wine

In a logarithmic specification

$$\log(q) = a + b \times \log(I) - c \times \log(p_1) + d \times \log(p_2) + e \times \log(p_3) + u$$

Where b, c, d, and e regression coefficients that directly represent the elasticities. Panel data from 5000 households supplied by the Gesellschaft für Marktforschung (Society for Market Research) (Das Weinjahr, different years) were used as data for estimation.

Because of different data availability, the relationship between price and quantity had to be estimated in a different way for the two other market segments. According to Lauenstein (1969), it is possible in a partial model to simplify the estimation procedure by taking price as the dependent variable. Therefore, it was assumed that the following relationship holds for these markets:

$P_{region} = f(S_{Germany,t}, S_{Germany,t-1}, S_{region,t}, S_{region,t-1})$

where

$P_{region}$ = real producer price in region r

$S_{Germany,t}$ = supply in the Fed. Rep. of Germany in the year t

$S_{Germany,t-1}$ = supply in the Fed. Rep. of Germany in the year t-1

$S_{region,t}$ = supply in the region r in the year t

$S_{region,t-1}$ = supply in the region r in the year t-1

Logarithmic functions were estimated analogous to the function presented above. However, in this case the coeffi-

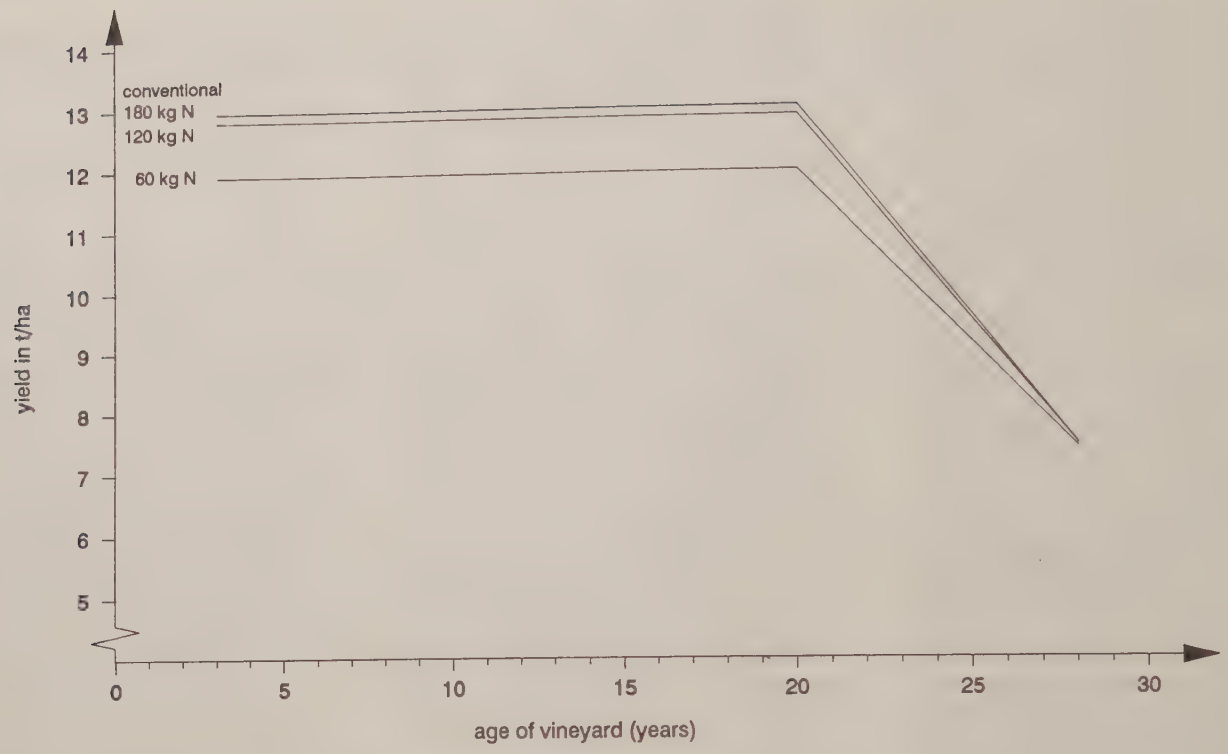



Figure 1. Yield as a function of age and nitrogen input.

Table 1: Factor capacities of the model wine farms

| | with direct marketing | without direct marketing |
|---|---|---|
| labor units/farm[a] | 1.75 | 1.75 |
| grape acreage (ha) | 5.0 | 6.0 |
| labor units/ 100 ha | 35.0 | 29.2 |

[a] 1 labor unit equals 2,400 productive hours per year

Table 2: Cost of fertilizers and pesticides (DM/ha)[a]

| | Rheinhessen | Rheinpfalz | Baden | Average |
|---|---|---|---|---|
| **fertilizers** | | | | |
| organic | 411 | 508 | 715 | 545 |
| conventional | 439 | 687 | 622 | 583 |
| **pesticides** | | | | |
| organic | 590 | 602 | 498 | 563 |
| conventional | 722 | 623 | 546 | 630 |

[a] 1 DM equals 0,61 US $ (May 1990); organic data from survey, conventional data from LLFA Neustadt, 1988; Bundesregierung, 1988.

cients to be estimated are price flexibilities, which are the reciprocal value of price elasticities. Data used were from statistical sources (Das Weinjahr, different years) for the years 1972-1985.

Labor and acreage are the same for conventional and organic models (Table 1). The farm models represent typical farms that can be expected to survive for the next 10 years as full-time operations under conventional management. Linear programming techniques were used to construct the models. The databa used for the farm models database a survey results, accepted industry sta dards, and statistical sources as indicat in the next section of the paper.

Figure 2 shows the general structu of the linear programming models. T production activities are per hectare grapes grown and harvested, with given variety and a given amount of f tilizer applied (for conventional). Th are restrictions that guarantee a mi mum diversity of varieties. The prod tion activities make use of existing la labor, machinery, and quota (if re vant). Labor capacity and use was vided into six different seasonal ti spans. This is important because problem of seasonal peak labor dema limits certain production activities. F example, to plant a vineyard, a hi amount of labor is needed in the spri which limits the amount that can planted in a given year.

In period 1, an average mix of variet and age of the vine operation is assum The decision to be made in this perio at what age the vineyard will be uproo and planted with new grapes. This is

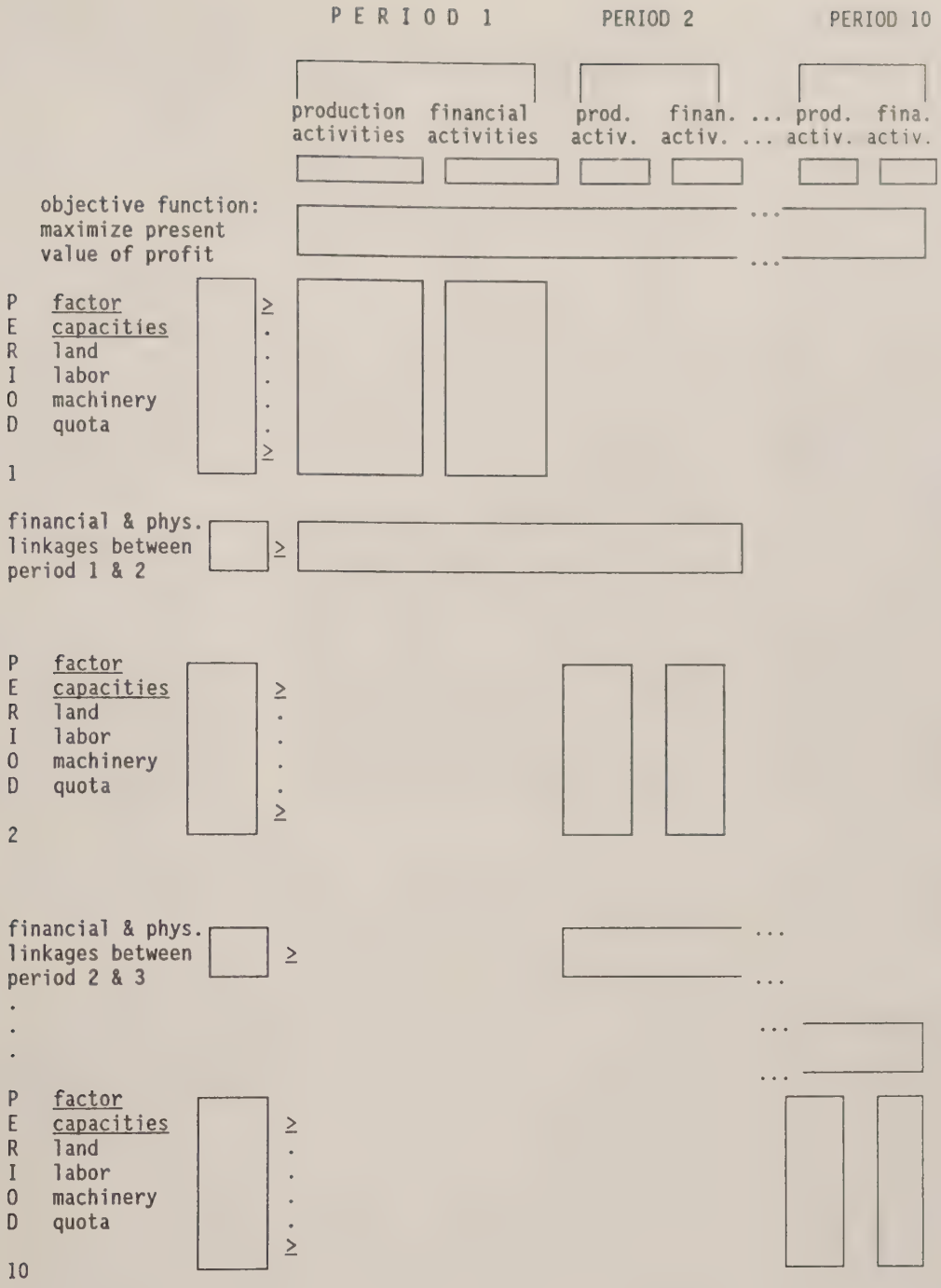



Figure 2. Structure of the linear programming farm models.

physical linkage to the next year. In period 2, a decision is made to plant a certain variety. In the first two years, there is no yield, but a large amount of labor and capital is needed to plant the vineyard. The financial linkages transfer the profit of a certain year either into savings or into investment. Investments can be made on credit.

## Results

### Expenses for fertilizers, pesticides, machinery, and buildings

Organic vine growers buy different organic fertilizers and they also use pesticides. Only non-synthetic pesticides may be used, the most important being copper and sulphur. The use of copper is limited to a maximum of 3 kg/ha per year. The costs of these pesticides are only slightly lower than the respective costs for conventional farmers (Table 2).

Machinery and necessary buildings are largely identical on organic and con-

Table 3. Fixed costs for machinery and buildings for a 6 ha grape operation[a]

| | grapes sold to cooperative | wine sold by the barrel | bottled wine |
|---|---|---|---|
| | | (DM/year) | |
| organic | 20,743 | 29,982 | 42,812 |
| conventional | 20,151 | 29,390 | 42,220 |

[a] Calculations based on survey results (organic) and accepted industry standards (conventional) (KTBL, 1986).

Table 4: Relative yields of organic grape operations by region (conventional = 100)[a]

| | |
|---|---|
| Rheinhessen | 78 |
| Rheinpfalz | 66 |
| Baden | 78 |

[a] Survey data; Das Weinjahr, various years.

ventional vine operations. However, some additional machinery is necessary on organic farms, so the overhead for machinery and buildings tends to be slightly higher than on conventional farms. These costs depend on the kind of product sold (Table 3).

### *Labor requirements*

Labor requirements per hectare are practically identical on organic and conventional farms if the labor needed for the harvest is not taken into account (327.6 hours/ha compared to 330 hours/ha) (KTBL, 1986, and survey results). More labor is needed on organic farms to handle voluminous organic manure and for weed control. However, less is needed for summer cutting, because the grapevines grow slower, and for soil management.

These results change if the labor needed for harvest is taken into account. Mechanized harvest is not allowed on organic grape operations, mainly to avoid soil compaction from heavy machinery. However, it is becoming more and more popular on conventional farms (Binder and Maul, 1988). The time needed for hand harvesting rises approximately proportionally with the amount harvested per hectare.

Because organic farms have lower yields, less labor is needed for hand ha vesting than on conventional farms. T labor requirement for marketing and c lar housekeeping is again proportional the quantity handled, which means le labor is needed on organic farms on per hectare basis. An overview on tot labor requirements is presented in Figu 3.

### *Yields*

Yield data were available for 5 yea on every farm because there is a law r quiring grape growers to keep record It is important to keep in mind that th figures presented on yields are five-ye averages; there are major yield fluctu

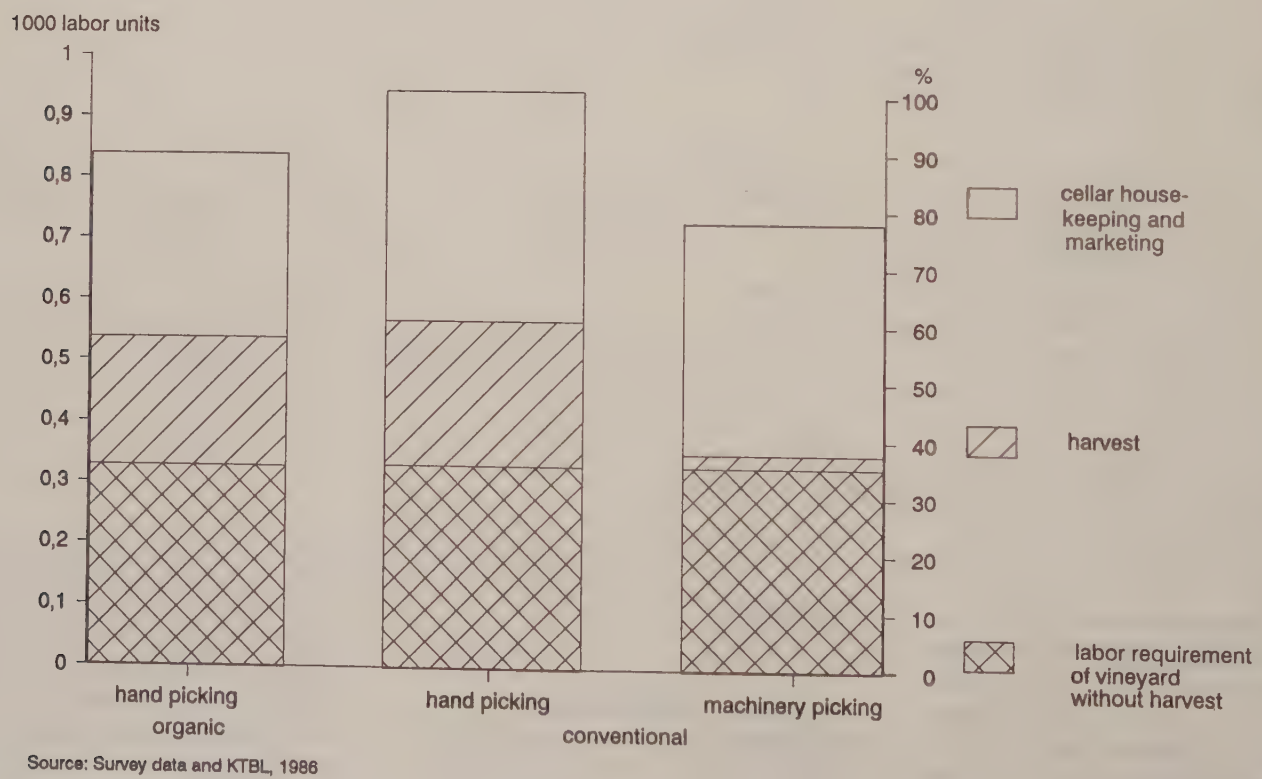



Figure 3. Labor requirements for wine operations with direct marketing of bottled wine in Rheinhessen (hours per hectare).

Table 5: Quality categories as a % of total, by region (average 1982–1986)[a]

| | Rheinhessen | Rheinpfalz | Baden |
|---|---|---|---|
| **Tafelwein** | | | |
| organic | 0.6 | 0.8 | 1.7 |
| conventional | 1.9 | 7.9 | 6.9 |
| **Qualitätswein** | | | |
| organic | 44.7 | 47.3 | 54.3 |
| conventional | 60.1 | 64.3 | 61.5 |
| **Qualitätswein mit Prädikat** | | | |
| organic | 54.7 | 51.9 | 44.0 |
| conventional | 38.0 | 27.8 | 31.6 |

[a] Organic data from survey; conventional data from Das Weinjahr (1987).

tions because of weather conditions.

*Yields* are lower on organic farms (Table 4); however, *quality* is better. There are three standardized qualities: Tafelwein (table wine), Qualitätswein (vintage wine), and Qualitätswein mit Prädikat (vintage wine with distinction). The first type is the lowest quality, the last is the highest (Table 5). The basis for this distinction is the German wine law. The wines are distinguished by "Oechsle degree," which indicates the weight of the must and is a measure of the natural sugar content. The more natural sugar the must contains, the higher the quality. However, the sugar content of the must does not necessarily give an indication of the sweetness of the resulting wine, which depends on how the wine is processed.

### Marketing and prices

Table 6 shows that organic producers market most of their wine in bottles either directly to consumers or through health food shops. The reason that organic grape growers market directly is to get a premium price. Up to now it has not been possible to establish an "organic quality" within the other market channels.

The price premiums organic grape growers receive are shown in Figure 4, which indicates the percentage of wine sold through the three different marketing channels by organic and conventional growers. The premiums they achieve in the market for grapes and wine by the barrel are only due to the objectively measurable higher quality, as described above. The premium they can achieve by selling bottled wine also contains a margin paid by the consumers for the organic production methods used.

### Regression results

Price elasticities and flexibilities are the regression coefficients of Tables 7

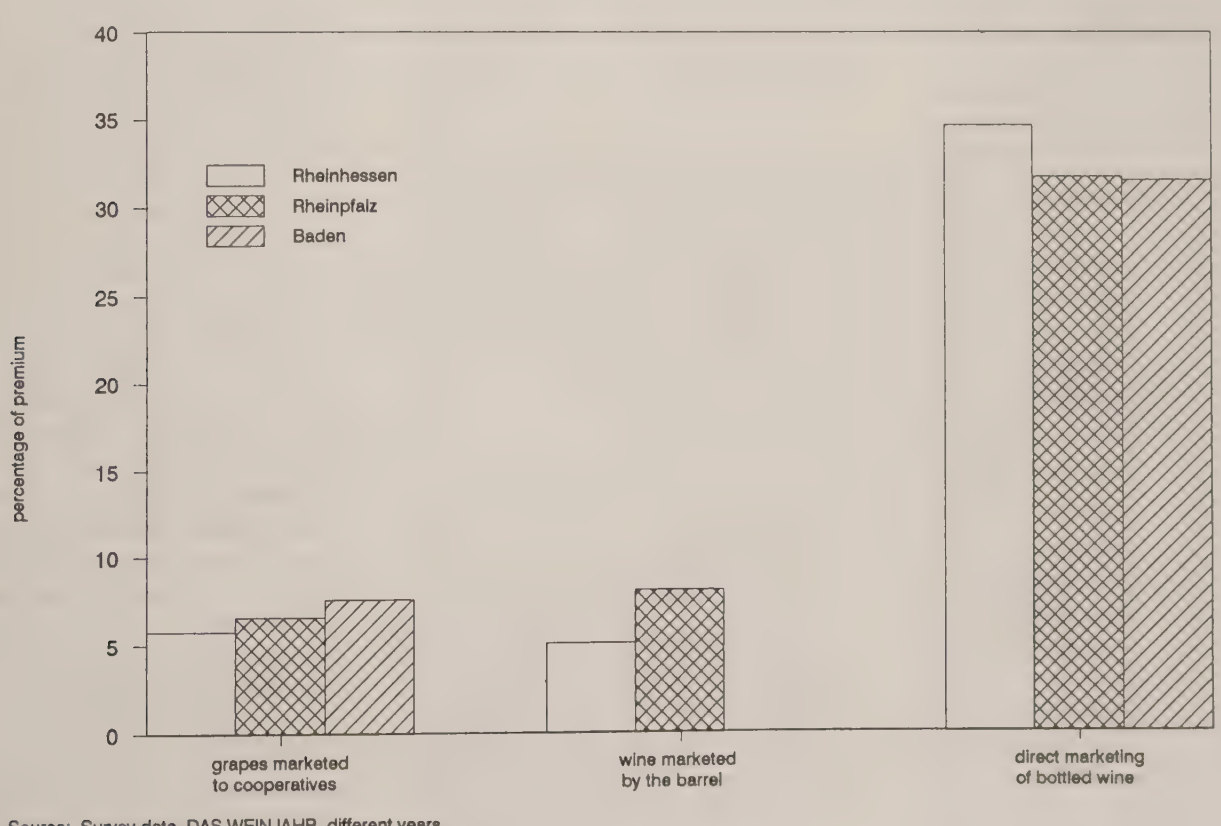



Figure 4. Premium for organically produced wine over conventionally produced wine (in %).

Table 6: Percentage of wine sold through the three different marketing channels by organic and conventional growers

| | grapes sold to cooperative | wine sold by the barrel | bottled wine |
|---|---|---|---|
| **Region Rheinhessen** | | | |
| organic | 0.0 | 5.6 | 94.4 |
| conventional | 12.0 | 54.0 | 34.0 |
| **Region Rheinpfalz** | | | |
| organic | 1.5 | 8.0 | 90.5 |
| conventional | 27.0 | 37.0 | 36.0 |
| **Region Baden** | | | |
| organic | 15.0 | 0.0 | 85.0 |
| conventional | 84.0 | 1.0 | 15.0 |

Source: Survey data of Hoffmann (1988).

Table 7: Logarithmic regression results explaining wine prices for the marketing channels "grapes sold to cooperatives" (1) and "wine by the barrel" (2)

| | a | yield Germany year t | yield region year t | yield Germany year t-1 | yield region year t-1 | trend | $R^2$ |
|---|---|---|---|---|---|---|---|
| Rheinhessen | | | | | | | |
| (1) | 2.43 | | −0.44*** | −0.32*** | | | 0.52 |
| (2) | 2.64 | | −0.55** | −0.34* | | | 0.79 |
| Rheinpfalz | | | | | | | |
| (1) | 2.60 | −0.49*** | | | −0.51*** | | 0.83 |
| (2) | 2.98 | −0.58*** | | | −0.74*** | | 0.82 |
| Baden | | | | | | | |
| (1) | 12.71 | | −0.44*** | −0.48** | | −9.41*** | 0.85 |

* significant at the 90% level.
** significant at the 95% level.
*** significant at the 99% level.

Table 8: Logarithmic regression results explaining quantity of demand for wine marketed directly to the consumers

| | a | income | Price of wine in the region | trend | $R^2$ |
|---|---|---|---|---|---|
| Rheinhessen | −0.14 | +2.36* | −1.05** | −4.68* | 0.51 |
| Rheinpfalz | −2.53 | +0.76** | −0.77** | | 0.63 |
| Baden | −6.85 | +1.76*** | −1.01*** | | 0.92 |

* significant at the 90% level.
** significant at the 95% level.
*** significant at the 99% level.

and 8. They can be used to estimate the change in prices if quantity changes because of the quota. They were inputs into the linear programming models for typical farms. An example will illustrate their meaning: If the price for wine marketed directly to the consumer rises by 1 percent, the quantity sold will only decline by 0.76 percent if all other factors remain equal. Similarly, a decline in quantity by 1 percent will lead to a 1.32 percent increase in price.

### *Results of whole-farm calculations*

Farm profit under different circumstances resulting from the model calculations are presented in Table 9. In most situations, the quota leads to an increase in profits. Only for conventional farms in Rheinpfalz that sell grapes to a cooperative will a quota lead to a small decrease in profit (from 46,583 DM per farm to 44,453 DM per farm). The reason is that these farms have to cut down on production more than in other r gions. In Baden, the quota does not b come binding for farms with direct ma keting. Since we assumed that the pri with direct marketing is not affected b an increase of other wine prices, there no change in profits.

The quota system favors the transitio to organic grape production for farm that sell their product to cooperatives grapes or as wine by the barrel. Howeve organic production still is not an ec nomical alternative for these farms b cause total profit is too low to sustain th farm under organic management, and is still lower than under convention management. With direct marketing bottled wine, the influence of the quo depends on the amount that productio must be reduced and on the resultin effects on conventional and organic wi prices.

Organic production is only econom cal with direct marketing. Farms wit out direct marketing of bottled wi would suffer serious losses in profit in a three regions if they changed to organ production. The transition to organic v ticulture can be profitable, however, these farms start with direct marketin

Farms that sell bottled wine direct to the consumers will improve their pro its in Rheinhessen and Baden if the change to an organic system. In Rhei pfalz, they will suffer a loss. As a cons quence of the quota and the strong d cline in production, the price f conventionally produced wine will ri strongly in this region. As nothing known about the effect this will have o the price of organic wine, it was assume in the calculations that there is no effec Even if total profit on organic operatio is lower than conventional, profit is st high enough to sustain the farm. If, co trary to this assumption, the price of o ganic wine rises as a result of the ri of the price for conventional wine, th profitability of organic wine productio would increase and might even surpa the profitability of conventional wi production in this region with dire marketing.

With respect to competitive adva tage, it seems likely that wine operatio in favored locations within a given r gion are more likely to increase the

Table 9: Results of the economic models: Average profit (DM per year over a ten year-period) for organic and conventional grape operations, with and without quota, by region and marketing channel.

| | conventional | | organic | |
|---|---|---|---|---|
| | with quota | without quota | with quota | without quota |
| Rheinhessen | | | | |
| — grapes sold to cooperative | 30,334* | 29,367 | 16,990 | 15,431 |
| — wine sold by the barrel | 18,259* | 16,734 | 6,090 | 4,094 |
| — direct marketing of bottled wine | 42,629* | 42,482 | 55,778 | 55,778 |
| Rheinpfalz | | | | |
| — grapes sold to cooperative | 44,453* | 46,583 | 24,269 | 19,277 |
| — wine sold by the barrel | 34,844* | 32,824 | 16,800 | 8,378 |
| — direct marketing of bottled wine | 73,911* | 65,922 | 61,740 | 61,740 |
| Baden | | | | |
| — grapes sold to cooperative | 28,085* | 26,498 | 15,617 | 13,886 |
| —direct marketing of bottled wine | 82,258 | 82,258 | 91,662 | 91,662 |

* indicates that the quota limits production
For comparison: Profit per grape operation was at 32,866 DM for all German full-time grape operations in the economic year from July 1988 to June 1989 (Bundesregierung, 1990).
Profit is return to labor and capital. Profit is calculated by deducting variable costs (fertilizers etc.) and fixed costs (for machinery and buildings) from gross returns.

profit by going organic than those in less favored locations. These producers already achieve high yields and must greatly reduce production because of the quota. Thus, the difference between conventional yields under the quota system and organic yields is small, while the price for organic wine is considerably higher.

## Summary and conclusions

The survey results indicate that organic vine operations achieve lower yields but produce a higher quality of wine as measured by the objective standards provided by the German wine law. To cover their costs, they must receive a premium price. Currently, this is only possible if the farmer produces bottled wine and sells it directly to the consumer.

The quota system generally favors the relative profitability of organic methods. However, this effect depends very much on the effect a price increase for conventional wine will have on the price of organic wine. If the percentage premium for organic wine stays the same, the quota system would favor organic production. If the price for organic wine is not affected by the rise in the price of conventional wine, as was assumed in the calculations presented above, with inelastic demand (Rheinpfalz and direct marketing) the quota system would negatively affect the relative profitability of organic wine.

Through direct marketing, organic viticulture can be an economically feasible alternative in many locations. The future development of organic viticulture will largely depend on the future price for organic wine relative to the price of conventional wine.

### References


1. Binder, G., and D. Maul. 1988. Vollerntereinsatz zur Rotweinlese (Mechanized harvest of red grapes). In Weinwirtschaft-Technik 1988, Heft Nr. 9, 133-149.
2. Bundesregierung. 3 various years. Agarbericht (Yearly Governmental Report on the Status of the Agricultural Sector of the Federal Republic of Germany).
3. Dabbert, S. 1990. Zur optimalen Organisation alternativer land-wirtschaftlicher Betriebe. Untersucht am Beispiel organisch-biologischer Haupterwerbsbetriebe in Baden-Württemberg. (The Optimum Organization of Organic Farms: The Example of Full-Time Organic Farms in Baden-Württemberg). Agarwirtschaft Sonderheft 124. Frankfurt am Main.
4. Das Weinjahr. Various years. Namen, Daten, Fakten. (The Wine Year: Names, Dates, Facts). Verlag Meininger, Neustadt an der Weinstrasse.
5. Hamm, U. 1987. Der alternative Landbau - ein interessantes Betätigungsfeld für Agrarökonomen und Agrarpolitiker. (Organic agriculture - an interesting area for agricultural economists and politicians). Agrarwirtschaft Jahrgang 36, Nr. 7/8, 255-260.
6. Hoffmann, D. 1986. Wirtschaftliche Aspekte eines integrierten, ökologischen Weinbaus. (Economic aspects of integrated, ecological wine production). In Qualitätsbewusster und ökologisch orientierter Weinbau, KTBL-Schrift 310, Darmstadt, pp. 129-135.
7. Hoffmann, D. 1988. Personal communication, Fachhochschule Geisenheim.
8. Kiefer, K. 1986. Durchführung des ökologischen Weinbaus - Ergebnisse einer Betriebsbefragung in der Bundesrepublik Deutschland. (Experiences with Organic Viticulture - Results of a Survey in the Federal Republic of Germany). Diplomarbeit Geisenheim.
9. KTBL. 1986. Datensammlung für Weinbau und Kellerwirtschaft. (Data Collection for Viticulture and Cellar Management). Landwirtschaftsverlag Münster-Hiltrup.
10. Lauenstein, M. 1969. Parameter-Restriktionen in der empirischen Nachfrageanalyse. (Parameter restrictions in the empirical analysis of demand). Statistische Hefte Heft 3.
11. LLFA Neustadt an der Weinstrasse. 1988. Farm accounts, different years: Special analysis of farm accounts of only vine producing operations.
12. Oberhofer, J. 1989. Betriebswirtschaftlicher Vergleich konventionell und ökologisch wirtschaftender Weinbaubetriebe in den Anbaugebieten Rheinhessen, Rheinpfalz und Baden unter besonderer Berücksichtigung der Hektarhöchstertrag-Regelung. (Economic comparison of conventional and organic viticulture in the regions Rheinhessen, Rheinpfalz and Baden with special reference to the new wine quota). Dissertation Universität Hohenheim.
13. Statistics Department of Rheinland-Pfalz - Bad Ems. 1989. Personal communication.
14. Stiftung Ökologischer Landbau. 1985. Rahmenrichtlinien zur Erzeugung von Trauben, Saft und Wein aus ökologischem Anbau. (Guidelines for organic grape, juice and wine production). IFOAM 54:19-21.
15. Stiftung Ökologischer Landbau. 1986. Rahmenrichtlinien für die Erzeugung von landwirtschaftlichen Produkten aus ökologischem Landbau in der Bundesrepublik Deutschland. (Guidelines for Organic Agricultural Production in West Germany). IFOAM 59:5-10.

# Mechanical and cultural weed control in corn and soybeans

Jeffrey L. Gunsolus

Abstract. *Many farmers and consumers are reevaluating chemical weed control because of the environmental risks of herbicides and their influence on farm size and diversity. This paper reviews research of the last 35 years on mechanical and cultural weed control in corn (*Zea mays *L.) and soybeans (*Glycine max *L.). Soybeans can better use the weed control advantages of late planting and narrow row spacing and are less affected by early stand losses from mechanical weed control. In Minnesota, delaying planting to early June allows early germinating weeds to be controlled by preplant tillage but reduces the maximum yield potential of corn by approximately 25 percent and soybeans by approximately 10 percent. Narrow rows allow the crop canopy to close earlier, preventing emerging weeds from developing. However, in a nonchemical weed control system, the row spacing should allow for inter-row cultivation to control weeds that emerge with the crop. Up to a 10 percent reduction in crop stand may be expected in fields that have been rotary hoed. In Minnesota, a 10 percent stand loss results in a 2 percent loss of corn yield potential and no loss of soybean yield potential. Successful mechanical weed control is directly related to the timeliness of the operation. Rotary hoeing is effective on weeds that have germinated but not yet emerged but not on weeds that germinate from deeper than 5 cm, on no-till fields, or on fields with more than 20 to 30 percent crop residue. Inter-row cultivation is most effective on weeds up to 10 to 15 cm tall. Successful nonchemical weed control requires highly refined management skills and is as much an art as a science.*

Key words: mechanical weed control, cultural weed control, corn, soybeans, planting date, row spacing, crop rotation, crop stand loss, timeliness

## Introduction

Weeds are highly opportunistic plants that are unwanted simply because they are growing at the wrong time or in the wrong place. Several strategies have been developed to control weeds, including mechanical, cultural, and chemical practices. Mechanical practices include primary and secondary tillage, rotary hoeing, and inter-row cultivation. Cultural practices include crop rotation and the manipulation of crop planting date, row spacing, and seeding rate to improve the competitive advantage of a crop over weeds. Chemical weed control primarily involves soil-applied and foliar-applied herbicides, but production of allelopathic chemicals by cover crops such as winter rye (*Secale cereale* L.) could also be considered a kind of chemical control.

Crop producers make weed control decisions based on many factors, such as effectiveness of control, time and labor constraints, risks associated with the failure of the treatment, and cost. For some producers, personal values and environmental factors play a role. As a result, many crop producers and consumers are evaluating weed control alternatives because of the environmental risks associated with herbicide use and its influen on the size and diversity of the farmi operation.

This paper reviews the scientific search conducted over the last 35 yea on cultural and mechanical weed contr in corn and soybeans, with the inte of making this information relevant a practical for corn and soybean produce of the Midwestern states. The princip of cultural and mechanical weed contr will be emphasized to provide inform tion needed by the crop producer make decisions about nonchemical we control.

## Cultural weed control practices

Nonchemical control of weeds is ge erally a much greater challenge in co than in soybeans. Granatstein (198 noted that corn is a most difficult cr in which to begin a successful transitio to a nonchemical farming system. So beans are better because of several pro erties that give them an advantage ov developing weeds. Soybeans can b planted later in the growing season, ha a greater yield potential in narrow ro spacings, are less affected by early seaso stand loss, and do not require an extern source of nitrogen. The following se tions explain how these factors influenc weed growth and development.

### Crop planting date

Germination of weed seeds depend on soil temperature, soil moisture, an seed dormancy. Conditions suitable f germination differ for each weed specie The germination of many "early season weed species begins in late April, peak in mid-May, and tapers off into earl June. Many weeds common to Midwes

Minnesota Agricultural Experiment Station Scientific Journal Series No. 18,419.

Jeffrey L. Gunsolus is Assistant Professor, Department of Agronomy and Plant Genetics, University of Minnesota, St. Paul, MN 55108.

ern corn and soybean fields are included in this category, including foxtails (*Setaria* spp.), common lambsquarters (*Chenopodium album* L.), redroot pigweed (*Amaranthus retroflexus* L.), and wild mustard (*Brassica kaber* (D.C.) L.C. Wheeler).

Delaying the crop planting date will enable a producer to control early germinating weeds with preplant tillage. Also, crops planted after mid-May will be developing when many early season weeds are experiencing a decline in germination (Chepil, 1946; Stoller and Wax, 1973). Unpublished research by Buhler, Ralston, and Gunsolus, from the University of Minnesota, illustrates this point. Soybeans planted May 12, 1989, in treatments without weed control, had 13 common lambsquarters/$m^2$, 38 redroot pigweed/$m^2$, and 74 giant foxtail (*Setaria faberi* Herrm.)/$m^2$. Soybeans planted June 2, 1989, had 2 common lambsquarters/$m^2$, 14 redroot pigweed/$m^2$, and 18 giant foxtail/$m^2$. The weed densities were taken on July 3, 1989. All treatments were disked in late April, 1989, and again prior to each planting. Soybean yields were 470 kg/ha and 1747 kg/ha from the May 12 and June 2, 1989, planting dates, respectively. Note the dramatic reduction in weed pressure and the corresponding increase in soybean yield from the May 12 to the June 2 planting dates. These data show the periodicity of annual weed germination and emergence; each species experiences a peak germination flush sometime during the growing season, followed by diminished flushes (Chepil, 1946; Stoller and Wax, 1973).

Before the development of soil-applied herbicides in the 1960s, average planting dates for corn and soybeans were mid-May and early June, respectively. Soil-applied herbicides allowed the farmer to control the intense early season weed flushes more readily and thereby obtain the yield advantages from early planting. Today, Midwestern producers are encouraged to plant corn from late April to early May and to complete planting of soybeans by mid-May. Tables 1 and 2 list the average percent yield loss for delaying the planting dates of corn past May 1 and soybeans past May 10 in Minnesota. These data are the cumulative result of numerous studies conducted under weed-free conditions. Therefore, they do not take into account the interaction of planting date with weed emergence.

In Minnesota, many corn and soybean producers who do not use chemicals prefer planting corn around May 15 and planting soybeans between June 1 and June 15 (Fernholz, 1990). Therefore, producers who switch to nonchemical weed control practices and who delay the planting date will be balancing the potential yield gains from improved weed control (without the use of herbicides) against the yield losses attributed to delayed planting. Unfortunately, only the yield losses from delayed planting currently can be predicted with any certainty. Current weed science research aims to improve predictions of yield loss based on germination patterns of weed species and number of seeds in the soil.

Robinson and Dunham (1956) studied how multiple tillage operations before planting affect weed control in soybeans planted in early and late June. The tillage was done with a tandem disk and spiketooth harrow. The results indicate that, on plowed ground, multiple tillage passes prior to final seedbed preparation are not necessary for controlling many of the annual grasses and broadleaf weeds native to Minnesota. Therefore, if a producer is to practice nonchemical weed control, it is not necessary to keep a plowed field weed free up to the time of seedbed preparation. Shallow tillage just before planting should be sufficient. However, if soybeans are to be planted in mid-June or if fields have high weed populations, one early tillage may be required to prevent tall weeds from inhibiting seedbed preparation and depleting soil moisture.

Table 1. Percent yield loss at various calendar dates of corn planting for an optimum harvest stand of 74,074 plants/ha. (Adapted from Hicks, 1979).

| Planting Date | Yield Loss (%) |
|---|---|
| Before May | 0 |
| 1–10 May | 7 |
| 11–25 May | 13 |
| After 25 May | 24 |

### *Crop row spacing*

Hicks et al. (1970) demonstrated that, in a weed free system, corn yield is maximized at a row spacing of 0.76 m and soybean yield is maximized at 0.38 m or less, depending upon hybrid or variety. Wax and Pendleton (1968) investigated the effects of four soybean row spacings (0.25, 0.51, 0.76, and 1.02 m) and two weed control methods (herbicides and cultivation) on the yield of two soybean varieties. Soybean yields increased as row spacing decreased. Compared with the 1.02-m row, yield increases of 10 percent, 18 percent, and 20 percent were shown for 0.76-, 0.51-, and 0.25-m rows, respectively. Weed control by either herbicides or cultivation was more effective in 0.51-m rows than in 1.02-m rows. The 0.51-m rows had an advantage over 0.25-m rows in that they could be cultivated.

As a weed management tool, narrow row spacing is advantageous because it allows the crop canopy to close (i.e., overlap) earlier in the growing season, which produces low-light conditions that prevent newly emerging weed seedlings from developing. However, to realize full soybean yield potential, weeds that germinate at the time of crop emergence must be controlled. If it is likely that early season weed control practices will not be successful, a row spacing wide enough to allow field cultivation for weed removal is advantageous. Therefore, soybean producers who want the yield response associated with narrow row spacings must also consider the risk associated with poor early season weed control.

The development of effective herbicides has allowed some soybean produc-

Table 2. Percent yield loss at various calendar dates of soybean planting for an optimum seeding rate of 387,654 seeds/ha. (Adapted from Hardman et al., 1988).

| Planting Date | Yield Loss (%) |
|---|---|
| 10 May | 0 |
| 20 | 3 |
| 30 | 9 |
| 10 June | 18 |
| 20 | 30 |
| 30 | 43 |

ers to realize the high yield potential of narrow row soybeans. Research by Burnside and Colville (1964) showed that, when weeds are chemically controlled with chloramben (3-amino-2,5-dichlorobenzoic acid), 0.25-m row soybeans produced higher yields with less tillage than 1.02-m row soybeans. Peters et al. (1965) studied the relationship of soybean row spacing to the number of cultivations necessary when a soil-applied herbicide (chloramben) was used. Soybeans grown in 0.51- and 0.61-m rows needed only one cultivation; soybeans in 0.81- and 1.02-m rows needed two cultivations.

In general, if herbicides are to be eliminated from the management system, it would be prudent to plant the crop in rows wide enough to allow for cultivation. Failing to do so puts more pressure on the other early season weed control tool, the rotary hoe (discussed in the sections on mechanical weed control).

### Crop rotation

Crop rotation does not eliminate weeds, but it can limit a buildup of weed populations and prevent major shifts in weed species composition. By growing sequences of crops that differ in planting dates, harvest schedules, competitive characteristics, and soil management requirements, growth and reproduction of a given weed species can be disrupted (Liebman and Janke, 1990). MacHoughton (1973) conducted an experiment comparing weed seed composition of the soil after six years of continuous or rotational cropping of corn/wheat/soybeans. Standard cultural and mechanical weed control practices were used but no herbicides were applied. Continuous corn and wheat favored a buildup of giant foxtail seeds; continuous soybeans favored a buildup of giant foxtail and velvetleaf (*Aubutilon theophrasti* Medik.). The three-crop rotational sequence resulted in very small increases in giant foxtail and a decrease in velvetleaf. Monocultures maximize the opportunities for the best-adapted weed species to increase; crop rotation limits these opportunities.

The introduction of synthetic nitrogen sources in the late 1940s led to a decline in the use of nitrogen inputs via legumes in the crop rotation (Walker and Buchanan, 1982). The abandonment of crop rotation without suitable herbicides led to some intense weed problems (Slife and Wax, 1976).

Research by Johnson et al. (1989) indicates that nitrogen management practices may influence weed populations in corn and soybeans (Table 3). A significantly higher population of common lambsquarters occurred when fields were planted to corn rather than to soybeans. These researchers suggested that the higher population of common lambsquarters in corn resulted from nitrogen fertility. They hypothesized that the 168 kg/ha of nitrogen fertilizer applied as urea or ammonium nitrate before corn planting stimulated dormant lambsquarters seed to germinate. Laboratory studies support this explanation (Fawcett and Slife, 1978), but it has not been supported by field studies.

If nitrogen does influence the germination and development of weeds, it may be possible to improve weed control practices by applying the bulk of the nitrogen later in the growing season, after the primary weed flushes. Walker and Buchanan (1982) indicate that location of nitrogen placement also influences weed-crop interference; they suggest th manipulation of nitrogen inputs offe the potential to enhance weed contr in integrated weed management system Future research should be directed t ward how the type of nitrogen sour and time and location of nitrogen appl cation influence weed management.

## Mechanical weed control

### Soybeans

The following discussion of mechan cal weed control in soybeans is based c the extensive research by Lovely et a (1958) demonstrating how the timeline of rotary hoeing and cultivation in so beans is related to their effectivenes This study evaluated the timeliness these mechanical weed control practic under wet and dry field conditions an under narrow and wide row spacings.

A timely rotary hoeing included thr rotary hoe operations that began whe weeds had germinated but had n emerged (in the white). The first o curred 3 to 5 days after soybean eme gence. The second and third came at i tervals of 5 days after the first. Untime rotary hoeing included two rotary ho

Table 3. Weed population densities (plants/m$^2$), taken in early July, in untreated plots, as influenced b crop, averaged across four tillage systems on a clay loam soil near Waseca, MN, 1984-1985 (Adapted fro Johnson et al., 1989).

| Crop | Foxtail[a] | Common lambsquarters | Total wee |
|---|---|---|---|
| Corn | 230 | 100 | 360 |
| Soybeans | 210 | 40 | 270 |
| Significance level | 0.53 | 0.01 | 0.10 |

[a] Includes both green (*Setaria viridis* (L.) Beauv.) and giant foxtail.

Table 4. Weed control and soybean yield from rotary hoeing in solid-seeded soybeans, 1955–1957 (Adapt from Lovely et al., 1958).

| Rotary hoe passes | Weed dry weight | | Soybean yield | |
|---|---|---|---|---|
| | kg/ha | % reduction | kg/ha | % of maximu |
| Weed free | 0 | 100 | 2620 | 100 |
| Weedy check | 1858 | 0 | 1613 | 62 |
| Timely[a] | 529 | 72 | 2284 | 87 |
| Untimely[a] | 1157 | 38 | 1949 | 74 |
| Timely, wet after | 1247 | 33 | 2150 | 82 |
| Untimely, wet after | 1394 | 25 | 1881 | 72 |
| Timely, wet before | 1247 | 33 | 2419 | 92 |
| Untimely, wet before | 1662 | 11 | 1881 | 72 |
| LSD (0.05) | — | — | 202 | — |

[a] Timely rotary hoeing performed three times; untimely rotary hoeing performed two times.

ing operations that began when weeds had emerged and had from one to three leaves. The second rotary hoeing came 5 days after the first. Table 4 demonstrates the effectiveness of the rotary hoe for the control of many annual weeds in narrow row soybeans. Without a rotary hoeing the weed infestation averaged 1,858 kg/ha of dry matter at maturity and soybean yield was 62 percent lower than in the weed-free plots. Timely rotary hoeing reduced the weed infestation by 72 percent and increased soybean yields by 671 kg/ha. Untimely rotary hoeing (after weeds had emerged) reduced weed infestations by only 38 percent and increased soybean yields by 336 kg/ha. Table 4 also demonstrates that wet soil conditions, 0.6 cm of water either 2 hours before or after timely rotary hoeing, resulted in nearly the same final weed populations as the untimely rotary hoeing. The effectiveness of the untimely rotary hoeing was reduced even further by wet soil conditions before or after the operation.

Table 5 summarizes a two-year study investigating the combination of timely and untimely rotary hoeing and two cultivations in 1.02-m row soybeans. The results in Table 5 indicate that two cultivations alone did not provide adequate weed control. However, three timely rotary hoeings followed by two cultivations provided weed control and yields comparable to the weed-free treatment. Two untimely rotary hoeings followed by two cultivations were not as effective as a timely rotary hoeing with cultivation, resulting in more weeds remaining at harvest. However, soybean yield was not significantly affected.

Lovely et al. (1958) also evaluated the influence of a preemergence herbicide in the rotary hoe/cultivation system and concluded that a preemergence herbicide followed by one cultivation 4 weeks after planting provided weed control equal to three timely rotary hoeings followed by two cultivations. In other words, the soil-applied herbicide was the weed control equivalent of three rotary hoeings and one cultivation. Combining two or three of the control measures (including untimely rotary hoeing) resulted in yields equivalent to the weed-free treatment. The authors also noted that control of early developing weeds with timely rotary hoeings may delay the need for cultivation and also permit more rapid and effective cultivation, thereby reducing the time and labor required.

In the study by Lovely et al. (1958), there was up to a 10 percent reduction in soybean stand because of some of the early rotary hoeings. However, the stand reduction was more than offset by the effective weed control that resulted from rotary hoeing at the proper stage of weed development (weeds in the white). Peters et al. (1959) reemphasized this point by showing that, when using rotary hoeing, timing by stage of weed development is more important than timing by stage of soybean development. However, they noted that soybeans should not be rotary hoed when the hypocotyl is just exposed at the soil surface (the crook stage). Their research also demonstrated severe crop injury and reduced yield in soybeans that were rotary hoed four times, with the final hoeing on 20 cm soybeans.

Table 5. Weed control and soybean yield from rotary hoeing and cultivation in 1.02-m row soybeans, 1956–1957 (Adapted from Lovely et al., 1958).

| Rotary hoe passes | Cultivations | Weed dry weight | | Soybean yield | |
|---|---|---|---|---|---|
| | | kg/ha | % reduction | kg/ha | % of maximum |
| Weed free | — | 0 | 100 | 2822 | 100 |
| Weedy check | — | 1792 | 0 | 1613 | 57 |
| None | 2 | 856 | 52 | 2284 | 81 |
| Three timely | 2 | 137 | 92 | 2755 | 98 |
| Two untimely | 2 | 337 | 81 | 2620 | 93 |
| LSD (0.05) | — | — | — | 202 | — |

Table 6. Corn yield response to rotary hoeing and cultivation in 0.76-m rows, planted on 3 May 1989, Waseca, MN (Adapted from Lueschen and Gunsolus, 1989).

| Rotary hoe passes | Cultivations | Herbicide | Corn Yield (kg/ha) |
|---|---|---|---|
| 0 | 0 | no | 2697 |
| 0 | 1 | no | 6459 |
| 0 | 2 | no | 6585 |
| 2 | 0 | no | 5707 |
| 2 | 1 | no | 8717 |
| 2 | 2 | no | 9344 |
| 2 | 2 | yes | 10,535 |

### *Corn*

There is less research literature on mechanical weed control in corn than soybeans. Studies that I have conducted in cooperation with agronomists at the University of Minnesota Branch Research Stations at Lamberton, Morris, and Waseca have attempted to fill this void. These studies were designed to be used in conjunction with a reduced rate of a preemergence herbicide. Therefore, the number of rotary hoe passes may be lower than would be needed in a nonchemical situation. Research results highlighting the nonchemical treatments from 1989 at Waseca, Minnesota, are summarized in Table 6. The rotary hoe operations were timely (weeds in the white); the first rotary hoeing took place 9 days after planting and the second occurred 4 days later. The single cultivations were done 4 weeks after planting. The two-cultivation treatments occurred 3 and 5 weeks after planting. The preemergence herbicide used was a tank mixture of 2.2 kg/ha of alachlor (2-chloro- N- (2,6- diethylphenyl)- N- (methoxymethyl) acetamide) and 2.2 kg/ha of cyanazine (2-[[4-chloro-6-(ethylamino)- 1,3,5- triazin- 2- yl]amino]-2-methyl propanenitrile) applied as a broadcast treatment.

Although no nonchemical weed control combinations equalled the combination of hoe, cultivation and herbicide, the rotary hoe contributed significantly to reducing yield loss. Cultivation also contributed to reducing yield loss, with the

greatest impact coming from the first cultivation. Heavy weed pressures associated with the early corn planting date may have prevented a better performance from the nonchemical treatments. The weed densities in the untreated control plots were: giant foxtail 968/$m^2$, common lambsquarters 32/$m^2$, and velvetleaf 11/$m^2$. Under such heavy weed pressures, a delayed planting date may be the best solution with nonchemical weed control.

### Crop stand loss

Reductions in crop populations due to rotary hoeing or cultivation are more detrimental to the yield of corn than soybeans. Tables 7 and 8 show the relationship of plant population and grain yield for corn and soybeans, respectively, under weed-free conditions. Note that a 7 percent corn stand loss results in a yield that is 97 percent of its full potential (Table 7). In soybeans, it takes a stand loss of approximately 25 percent to obtain the same 97 percent yield potential (Table 8). Therefore, more care should be taken to prevent early season stand losses due to rotary hoeing and cultivation in corn than in soybeans.

### Timeliness is the key

Timeliness is a key element in any weed control program. Therefore, it is very important for a producer to know the growth stage(s) of the weed when it is most vulnerable to each control practice. These vulnerable periods differ for each weed control practice and, unfortunately, some are shorter than others. The rotary hoe is most effective on weeds that have germinated but not yet emerged; this period is approximately 3 to 7 days after planting. Inter-row cultivation is most effective on weeds up to 10 to 15 cm tall; this period is approximately 3 to 5 weeks after planting. Soil-applied herbicides are only effective on weeds that have not yet emerged from the soil; this period is up to 7 days after planting. Postemergence herbicides are most effective on weeds up to 10 cm tall; this period is approximately 2 to 3 weeks after planting. These are general estimates, and results vary with herbicide, weed species, and environmental conditions.

These vulnerable periods mean it is important for an individual producer to evaluate time, labor, and equipment constraints and environmental factors that could delay timely control, such as wet field conditions or dairy herd maintenance. Table 9 (Doll et al., 1990) li the time needed to cultivate or rota hoe various crop areas based on equi ment size and speed. Bender (1986), farmer with extensive experience usi the rotary hoe as part of his nonchemic weed control program, suggests th planting dates be spread over time that the farmer does not plant more th can be rotary hoed in one day.

### Weed germination depth

Timely rotary hoeing will not effe tively control all annual weed speci Rotary hoes are much less effective controlling weeds capable of deep germ nation (greater than 5 cm below the s surface). To illustrate, in unpublished search conducted by Buhler and Ralst at the University of Minnesota in 1989 two-pass and one-pass rotary hoe syste was compared to an untreated contr plot. The first pass occurred 8 days aft soybean planting, the second pass 6 da later. Cocklebur (*Xanthium strumariu* L.) densities were 54/$m^2$, 64/$m^2$, and 5 $m^2$ for the untreated, one-pass, and tw pass treatments, respectively.

Deep germinating annual weeds su

Table 7. Potential corn yields in Minnesota for full-season hybrids planted before 1 May, expressed as a percent of the optimum harvest stand of 74,074 plants/ha and as a percent of a potential yield of 10,849 kg/ha. (Adapted from Hicks, 1979).

| Stand | Potential Yield |
|---|---|
| (% of optimum) | (%) |
| 100 | 100 |
| 93 | 97 |
| 80 | 92 |
| 73 | 88 |
| 60 | 79 |
| 53 | 74 |

Table 8. Potential soybean grain yields in Minnesota for full-season varieties planted during early May, expressed as a percent of the optimum seeding rate of 387,654 seeds/ha. (Adapted from Hardman et al., 1988).

| Stand | Potential Yield |
|---|---|
| (% of optimum) | (%) |
| 100 | 100 |
| 75 | 98 |
| 50 | 90 |
| 25 | 75 |

Table 9. Hours needed to cultivate or rotary hoe various areas of crops planted with equipment of varic sizes operated at specific speeds in 0.76-m row spacings (Adapted from Doll et al., 1990).

| Rows cultivated | Speed (m/s) | Hectares covered per hour | Hours to cultivate or rotary hoe indicated area | | | |
|---|---|---|---|---|---|---|
| | | | 20 ha | 30 ha | 40 ha | 80 |
| 4 | 1.3 | 1.5 | 13.3 | 20.0 | 26.6 | 53 |
| 4 | 1.8 | 2.0 | 10.0 | 15.0 | 20.0 | 40 |
| 4 | 2.7 | 2.9 | 6.9 | 10.3 | 13.8 | 27 |
| 4 | 3.6 | 3.9 | 5.1 | 7.7 | 10.3 | 20 |
| 6 | 1.3 | 2.2 | 9.1 | 13.6 | 18.2 | 36 |
| 6 | 1.8 | 2.9 | 6.9 | 10.3 | 13.8 | 27 |
| 6 | 2.7 | 4.4 | 4.5 | 6.8 | 9.1 | 18 |
| 6 | 3.6 | 5.9 | 3.4 | 5.1 | 6.8 | 13 |
| Rotary hoe width (m) | | | | | | |
| 4.5 | 2.7 | 4.4 | 4.5 | 6.8 | 9.1 | 18 |
| 4.5 | 3.6 | 5.9 | 3.4 | 5.1 | 6.8 | 13 |
| 4.5 | 4.5 | 7.4 | 2.7 | 4.1 | 5.4 | 10 |
| 4.5 | 5.4 | 8.8 | 2.3 | 3.4 | 4.5 | 9 |
| 6.0 | 2.7 | 5.9 | 3.4 | 5.1 | 6.8 | 13 |
| 6.0 | 3.6 | 7.9 | 2.5 | 3.8 | 5.1 | 10 |
| 6.0 | 4.5 | 9.8 | 2.0 | 3.1 | 4.1 | 8 |
| 6.0 | 5.4 | 11.8 | 1.7 | 2.5 | 3.4 | 6 |
| 8.5 | 2.7 | 8.2 | 2.4 | 3.7 | 4.9 | 9 |
| 8.5 | 3.6 | 11.0 | 1.8 | 2.7 | 3.6 | 7 |
| 8.5 | 4.5 | 13.7 | 1.5 | 2.2 | 2.9 | 5 |
| 8.5 | 5.4 | 16.5 | 1.2 | 1.8 | 2.4 | 4 |

as common cocklebur, velvetleaf, wild proso millet (*Panicum miliaceum* L.), sorghum-almum (*Sorghum almum* Parod.), wild oat (*Avena fatua* L.), and woolly cupgrass (*Eriochloa villosa* (Thunb.) Kunth.) are very difficult to control with a rotary hoe because they are so deeply anchored in the soil. A greater reliance on crop rotation, cultivation, and postemergence herbicides is needed to control these weeds.

### Reduced tillage

Successful rotary hoeing depends on preplant tillage operations (i.e., moldboard or chisel plowing) to establish a suitable seedbed. Springman et al. (1989) note that rotary hoes are not suited to no-till and many single-pass tillage operations. Stony, compacted, and cloddy surfaces can reduce the effectiveness of the rotary hoe. Residue cover above about 20 to 30 percent can also reduce its effectiveness. Ridge till systems, however, may be able to use the rotary hoe to reduce or eliminate herbicide use over the row.

C-shank and upgraded C-shank (also called heavy-duty) cultivators are capable of consistent weed control under reduced tillage (Springman et al., 1989). A well-designed and implemented cultivation system can help make conservation tillage profitable through reduced herbicide costs and increased yield response to cultivation. Perennial weed populations tend to increase in reduced tillage systems. Because of their established root systems, perennial weeds cannot be controlled by rotary hoeing. Therefore, cultivation and often postemergence herbicides are necessary.

Conflicting reports have been published regarding the yield responses of crops to cultivation. Most researchers cite weed control as the only reason to cultivate. Swanson and Jacobson (1953) could not find conclusive proof that cultivation was desirable except for weed control. However, research by Siemens and McGlamery (1985) at the University of Illinois attributed a significant increase in crop yield to improved soil aeration and water infiltration resulting from cultivation. The usefulness of cultivation for purposes other than weed control varies with weather, soil type, moisture stress, and soil crusting and compaction (Swanson and Jacobson, 1953).

## Nonchemical weed control--art or science?

It is apparent that nonchemical weed control is as much an art as a science. Science can help us explain why certain practices work the way they do and can define basic principles that can be used in predicting the outcome. However, weed control practices such as rotary hoeing and cultivation also require knowledge of how to accomplish a given task (e.g., adjusting equipment) on a given soil type under given soil conditions. This is the art of weed control.

Well-conducted science can contribute substantially to a farmer's knowledge. However, science can only assist, but not substitute for, the highly refined management skills that are necessary to develop and carry out a successful nonchemical weed control program.

#### References


1. Bender, J. 1986. Get the most from your rotary hoe. The New Farm. March/April:23, 25-27.
2. Burnside, O. C., and W. L. Colville. 1964. Soybean and weed yields as affected by irrigation, row spacing, tillage, and amiben. Weeds 12:109-112.
3. Chepil, W. S. 1946. Germination of weed seeds I. Longevity, periodicity of germination, and vitality of seeds in cultivated soil. Scientific Agriculture 26:307-346.
4. Doll, J., R. Doersch, W. Paulson, and T. Mulder. 1990. Effectiveness of substituting cultivation for herbicides. Proceedings of the Fertilizer, Ag Lime and Pest Management Conference 29:244-252.
5. Fawcett, R. S., and F. W. Slife. 1978. Effects of field applications of nitrate on weed seed germination and dormancy. Weed Science 26:594-596.
6. Fernholz, C. 1990. How I control weeds without herbicides. The New Farm. March/April: 17-20.
7. Granatstein, D. 1988. Sustainable farming: Making the transition. In Reshaping the Bottom Line: On-Farm Strategies for a Sustainable Agriculture. Land Stewardship Project, Stillwater, Minnesota. p. 6.
8. Hardman, L. L., J. H. Orf, G. W. Rehm, and W. C. Stienstra. 1988. Tips for profitable soybean production. University of Minnesota Extension Service, AG-FO-2899.
9. Hicks, D. R. 1979. Corn replanting: Is it necessary? University of Minnesota Agricultural Extension Service Crop News No. 46.
10. Hicks, D. R., H. J. Otto, and P. H. Hasbargen. 1970. Row width for corn and soybeans. University of Minnesota Extension Service, FS-AG-16.
11. Johnson, M. D., D. L. Wyse, and W. E. Lueschen. 1989. The influence of herbicide formulation on weed control in four tillage systems. Weed Science 37:239-249.
12. Liebman, M., and R. R. Janke. 1990. Sustainable weed management practices. In C. Francis, C. B. Flora, and L. D. King (eds.). Sustainable Agriculture in Temperate Zones. John Wiley and Sons, Inc., New York, New York. pp. 111-143.
13. Lovely, W. G., C. R. Weber, D. W. Staniforth. 1958. Effectiveness of the rotary hoe for weed control in soybeans. Agronomy Journal 50:621-625.
14. Lueschen, W. E., and J. L. Gunsolus. 1989. Effects of cultivation on corn weed control. University of Minnesota Southern Experiment Station Research Report. pp. 55-59.
15. MacHoughton, J. 1973. Ecological Changes in Weed Populations as a Result of Crop Rotations and Herbicides. Ph.D. dissertation, University of Illinois at Champaign-Urbana.
16. Peters, E. J., M. R. Gebhardt, and J. F. Stritzke. 1965. Interrelations of row spacings, cultivations and herbicides for weed control in soybeans. Weeds 13:285-289.
17. Peters, E. J., D. L. Klingman, and R. E. Larson. 1959. Rotary hoeing in combination with herbicides and other cultivations for weed control in soybeans. Weeds 7:449-458.
18. Robinson, R. G., and R. S. Dunham. 1956. Pre-planting tillage for weed control in soybeans. Agronomy Journal 48:493-495.
19. Siemens, J. C., and M. D. McGlamery. 1985. Effect of cultivation on central Illinois corn and soybean yields. Crops and Soils 37:13-16.
20. Slife, F. W., and L. M. Wax. 1976. Weed and herbicide management. In L. D. Hill (ed.). World Soybean Research. Interstate Printer & Publ., Inc., Danville, Illinois. pp. 397-403.
21. Springman, R., D. Buhler, R. Schuler, D. Mueller, and J. Doll. 1989. Row crop cultivators for conservation tillage systems. University of Wisconsin Extension A3483.
22. Stoller, E. W., and L. M. Wax. 1973. Periodicity of germination and emergence of some annual weeds. Weed Science 21:574-580.
23. Swanson, C. L. W., and H. G. M. Jacobson. 1953. Herbicides: A new tool for use in studying soil physical properties affecting crop growth. Weeds 1:174-184.
24. Walker, R. H., and G. A. Buchanan. 1982. Crop manipulation in integrated weed management systems. Weed Science 30 (Suppl. 1):17-24.
25. Wax, L. M., and J. W. Pendleton. 1968. Effect of row spacing on weed control in soybeans. Weeds 16:462-464.

# Economic impacts of extended grazing systems

G. E. D'Souza, E. W. Maxwell, W. B. Bryan, and E. C. Prigge

Abstract. *Extended grazing is a management system in which the usual grazing season is lengthened by utilization of hay fields for pasture. Extended grazing systems are a low-input alternative to conventional systems to the extent that they decrease the reliance on inputs such as machinery and energy to harvest forage. Substituting pasturing for harvested forage can therefore potentially decrease production costs and enhance the profitability of livestock production. However, the farm-level economic impacts of such a substitution are not well known. This analysis quantifies these impacts for beef cow/calf production. Specifying alternative meadow management systems for different grasses and using an economic-engineering approach, we have found that extended grazing can be a more profitable option for cow/calf production. Other findings suggest that, in an extended grazing system, the type of meadow, the hay baling method and the associated hay spoilage level also have important effects on production costs and profitability.*

Key words: meadow management, cow/calf production, reduced inputs, economic impacts

## Introduction

Extended grazing is a management system whereby hay fields (meadows) are grazed by livestock during portions of the year when hay traditionally is fed to the herd. The greater the duration of pasturing, the less the amount of forage that must be mechanically harvested to maintain animals over the winter. This can reduce input use and production costs and enhances profitability and is consistent with the reduced-input or low-input trend in agriculture.

The technical feasibility of extended grazing management has been established (Baker and Nestor, 1979; Baker et al., 1988; Wilman and Griffiths, 1978). However, the farm-level impacts of such an approach on cow/calf production costs and profitability have not be quantified. This study attempts to this gap.

We used a combination of prima data from grazing trials at West Virgi University and secondary economic da to analyze alternative meadow manag ment systems. The systems, consisting different grasses and length of pasturi were used to determine the optimum e tent to which pasturing can be subs tuted for wintering. These systems, t analytical procedure and data used, t results of the analysis, and some implic tions for decision making, are describ in the following sections.

## Meadow management systems

Four meadow management syste were evaluated. These are: (1) two c tings of hay, no grazing (HH); (2) o cutting of hay and late fall grazing (H (3) early spring grazing and two cuttin

Table 1. Description of meadow management systems analyzed and winter feed requirements for cows

| System | Description | Wintering |
|---|---|---|
| HH | two hay cuttings over summer, which are either sold or used to winter cows; no grazing | 9.1 kg hay/day/cow for first 90 days; and 12.4 kg hay/day/cow for last 60 days |
| HG | one hay cutting in summer, followed by late fall grazing | 9.1 kg meadow grazing/day/co for 60 days; followed by 9.1 kg hay/day/cow for 30 days; and 12.4 kg hay/day/cow for 60 da |
| GHH | early spring grazing, followed by two cuttings of hay | 9.1 kg hay/day/cow for 90 days followed by 12.4 kg hay/day/co for 40 days; and 12.4 kg meado grazing/day/cow for 20 days pr to usual turnout |
| GHG | early spring grazing, one hay cutting, and late fall grazing | 9.1 kg meadow grazing/day/co for 60 days; followed by 9.1 kg hay/day/cow for 30 days; 12.4 hay/day/cow for 40 days; and 12.4 kg meadow grazing/day/c for 20 days prior to usual turno |

Published with the approval of the Director of the West Virginia Agricultural and Forestry Experiment Station as Scientific Article #2202. This research was supported with funds appropriated under the Hatch and McIntire-Stennis Acts.

G. E. D'Souza is Assistant Professor and E. W. Maxwell is Former Graduate Research Assistant, Division of Resource Management; W. B. Bryan is Professor, Division of Plant Sciences; and E. C. Prigge is Professor, Division of Animal Sciences, West Virginia University, Box 6108, Morgantown, WV 26506.

of hay (GHH); and (4) early spring grazing, one hay cutting, and late fall grazing (GHG). These systems, in turn, were compared for two grasses, orchard grass (*Dactylis glomerata* L.) and tall fescue (*Festuca arundinacea* Schreb.).

The meadow management trial covered a 3-year period from 1981-84. A 5-month benchmark wintering period beginning in early December and continuing until late April was assumed for the systems. The winter feeding requirements for the systems that were analyzed are shown in Table 1. These requirements, based on National Research Council (1976) recommendations for pregnant and average lactating beef cows, resulted in a total dry matter requirement of 1,563 kg/cow over the 150-day wintering cycle.

Dry matter production for the meadow management systems analyzed is shown in Table 2. Total dry matter production (hay and grazed combined) per hectare was highest for the HG system and lowest for the GHH system, for both orchard grass and tall fescue. Further, production of tall fescue was consistently higher than orchard grass in hay and grazed dry matter. A more detailed description of the production data (including the experimental design, statistical methods, and differences among treatments) is reported in Baker et al. (1988).

## Analytical procedure and data

The first step in the economic analysis was the development of enterprise budgets for the production of calves under each system. A total of eight budgets were constructed, one for each meadow management system and grass. The technical production coefficients were obtained from the meadow management trial mentioned earlier. Hay harvesting costs were obtained from secondary sources (Eagan, 1986), and costs of production were compared for both round- and square-baling methods. Other secondary data sources include Baker et al. (1981), Layton et al. (1970), and the West Virginia Department of Agriculture (1986). All cost and revenue data

Table 2. Dry matter (DM) production for alternative meadow management systems, West Virginia, 1981–84 averages[a]

| System[b] | DM Production (1,000 kg/ha) | | |
|---|---|---|---|
| | Hay | Grazed | Total |
| Orchard grass | | | |
| HH | 6.95 | 0.00 | 6.95 |
| HG | 5.16 | 2.32 | 7.48 |
| GHH | 5.33 | 0.72 | 6.05 |
| GHG | 3.42 | 3.59 | 7.01 |
| Average | 5.22 | 1.66 | 6.88 |
| Tall fescue | | | |
| HH | 7.26 | 0.00 | 7.26 |
| HG | 5.12 | 2.69 | 7.81 |
| GHH | 5.99 | 1.12 | 7.11 |
| GHG | 3.53 | 4.22 | 7.75 |
| Average | 5.48 | 2.01 | 7.49 |

[a] Statistical differences among treatments and other statistical measures are contained in Baker *et al.* (1988)
[b] See Table 1 for a description of the systems

Table 3. Variable costs of production for alternative meadow management systems, by method of baling hay, West Virginia, 1986

| System[a] | Costs | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 23 kg (50 lb) Square Bales | | | | 682 kg (1,500 lb) Round Bales | | | |
| | $/ha | $/ton hay | $/ton DM[b] | $/kg calf | $/ha | $/ton hay | $/ton DM[b] | $/kg calf |
| Orchard grass | | | | | | | | |
| HH | 244 | 32 | 32 | 1.03 | 161 | 21 | 21 | .95 |
| HG | 164 | 29 | 20 | .92 | 103 | 18 | 12 | .86 |
| GHH | 203 | 35 | 30 | 1.03 | 140 | 24 | 21 | .95 |
| GHG | 121 | 32 | 16 | .90 | 80 | 21 | 10 | .84 |
| Average | 183 | 32 | 25 | .97 | 121 | 21 | 16 | .90 |
| Tall fescue | | | | | | | | |
| HH | 252 | 31 | 31 | 1.03 | 165 | 21 | 21 | .95 |
| HG | 163 | 29 | 19 | .92 | 102 | 18 | 12 | .86 |
| GHH | 220 | 33 | 28 | 1.01 | 149 | 22 | 19 | .92 |
| GHG | 123 | 32 | 14 | .88 | 81 | 21 | 10 | .84 |
| Average | 190 | 31 | 23 | .97 | 124 | 21 | 16 | .90 |

[a] See Table 1 for a description of the systems
[b] Total DM produced

Table 4. Optimal solutions for alternative meadow management systems, West Virginia, 1986.

| System[a] | No. of Cows | No. of Calves Sold | Returns above variable costs ($) |
|---|---|---|---|
| Orchard grass | | | |
| HH | 72 | 63 | 2,206 |
| HG | 78 | 68 | 3,966 |
| GHH | 63 | 55 | 2,066 |
| GHG | 71 | 62 | 4,097 |
| Average | 71 | 62 | 3,084 |
| Tall fescue | | | |
| HH | 75 | 66 | 2,355 |
| HG | 81 | 71 | 4,271 |
| GHH | 74 | 65 | 2,745 |
| GHG | 74 | 65 | 4,361 |
| Average | 76 | 67 | 3,433 |

[a] See Table 1 for a description of the systems

pertain to West Virginia and represent 1986 estimates.

The analysis is of a hypothetical representative farm engaged in cow/calf production. The farm has 16 ha of meadowland, all of which is to be allocated to one meadow management system at a given time. We assumed that sufficient summer pasture exists for the maximum number of cattle over-wintered. The basic question is which meadow management system will maximize profits (returns above variable costs) to the cow/calf producer. In this study, the farmer is assumed to use existing equipment and other fixed resources but can produce under any one of the four management systems and either of the two grasses.

Accordingly, eight linear programming (LP) models, corresponding to each system and grass, were used to determine the optimal meadow management system for the representative farm. The objective function was set up as follows:

maximize $Z = (R_{cf}) - (C_{cw} + C_m)$,

where Z represents revenues above variable or operating costs, $R_{cf}$ represents revenues generated from calf sales, $C_{cw}$ is the cost of maintaining cows during the year, and $C_m$ represents the cost of operating and harvesting meadows for a given system and type of grass. Negative levels of all activities were precluded, consistent with the usual assumptions of LP. Further details on the budgets, procedure, and data can be found in Maxwell (1988).

## Results

Results from the economic analysis of the meadow management systems are presented below for the following categories: production costs for each system corresponding to two methods of hay baling, the LP model solutions for the representative farm, and the impacts of hay spoilage on production costs.

### Production costs for alternative systems

The costs of production pertaining to each meadow management system for both round and square hay-baling methods are presented in Table 3. With the exception of costs on a per ton of hay basis, where the costs of system HG were the lowest, GHG was the least-cost system. This result is especially significant because, even though grazed dry matter was the highest for the GHG system, hay and total dry matter production were not the highest (Table 2). On the other hand, except for system GHH, which was associated with the highest costs on a per ton of hay basis, system HH was the highest cost system with respect to all other criteria, such as costs per hectare, per ton of dry matter, and per kilogram (kg) of calf produced. In general, except for costs on a per hectare basis, average production costs were lower for systems with tall fescue than those with orchard grass. Further, in all cases, production costs were lower for 682 kg (1,500 lb) round bale systems than for comparative 23 kg (50 lb) square bale systems. However, differences between the two methods of baling in spoilage and waste during feeding may partially offset these cost differences. The impacts that hay spoil-

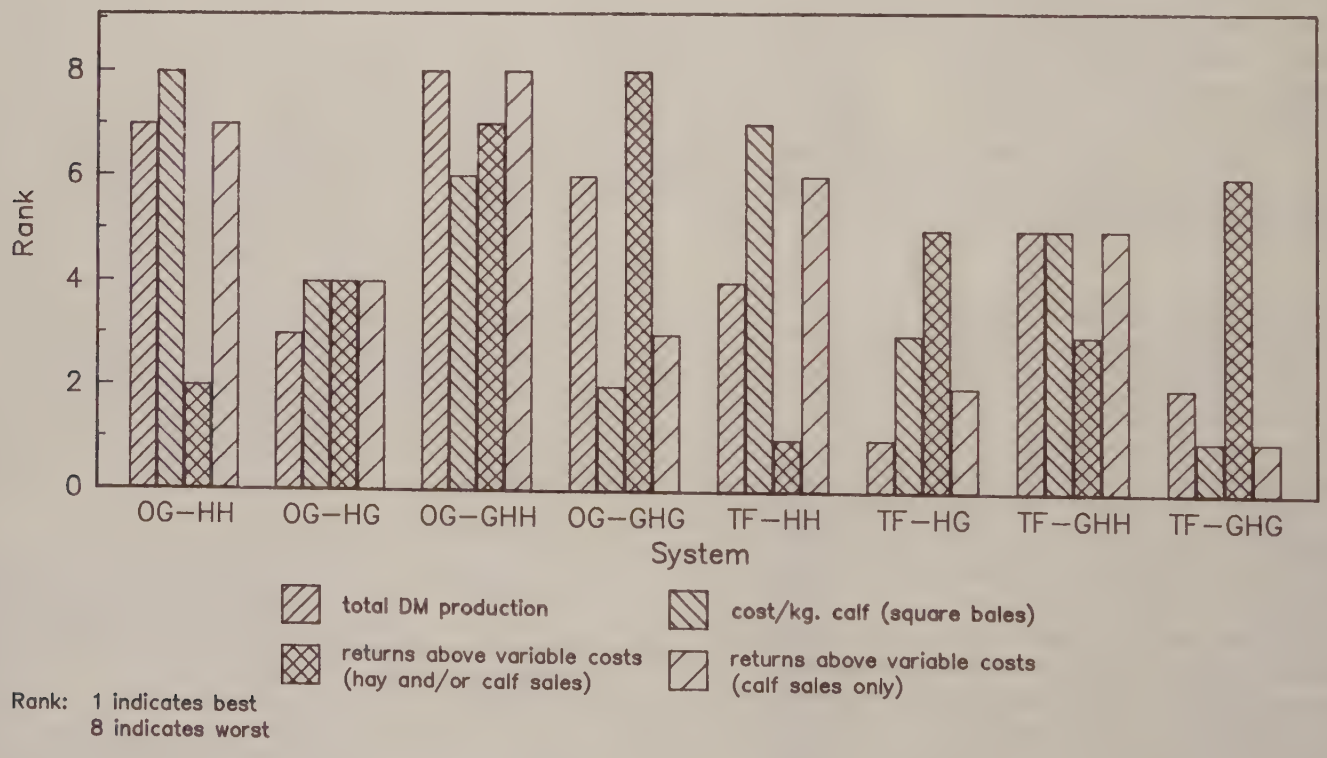



Figure 1. Rankings of alternative orchard grass (OG) and tall fescue (TF) meadow management systems with respect to dry matter production, costs and returns.

age with round and square hay baling have on calf and hay production costs are addressed in a later section.

### *Optimal solutions*

The LP model solutions for specific meadow management systems and grasses for the representative farm are shown in Table 4. System HG resulted in the greatest number of calves sold. This is consistent with the dry matter production results (Table 2), where total dry matter production was greatest for the HG system. However, the most profitable system in terms of returns to fixed resources was found to be the GHG system for both orchard grass and tall fescue, and the least profitable systems were GHH for orchard grass and HH for tall fescue. The average optimum solution value was higher for systems with tall fescue.

The relative rankings of alternative systems with respect to selected criteria such as dry matter production, costs per kg of calf produced, and returns above variable costs are summarized using an illustration (Figure 1).

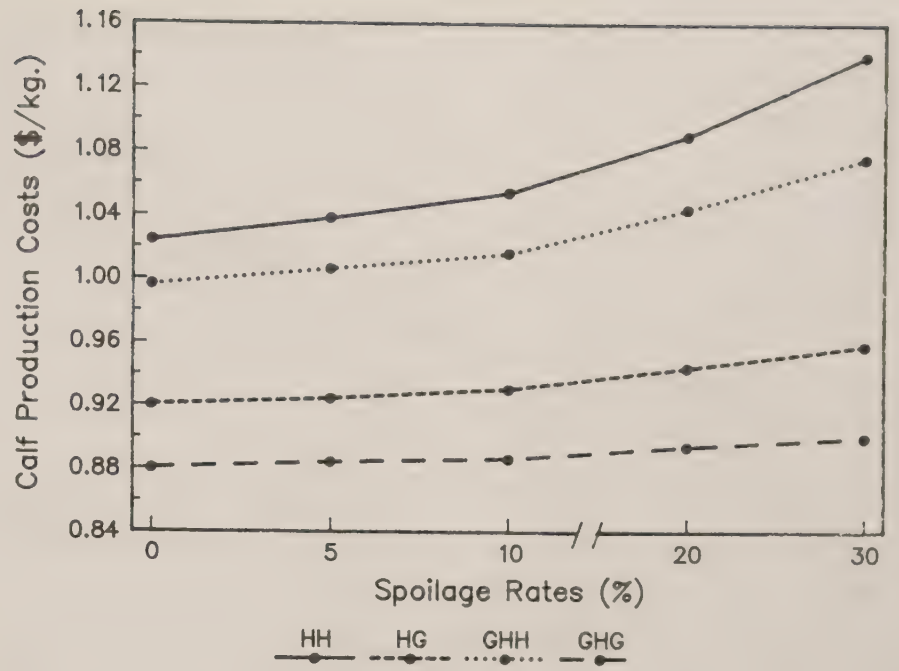



Figure 2. Impact of different levels of hay spoilage on variable calf production costs for alternative meadow management systems using tall fescue and square bales, West Virginia, 1986.

### *Impacts of hay spoilage on production costs*

This analysis of the meadow management systems assumes there are no differences between the round and square hay-baling methods other than cost. In reality, spoilage (used generically here to include shrink or other dry matter losses such as wastage during feeding) could result in other differences between these methods, the estimation of which is beyond the scope of this study. However, this analysis was extended to shed some light on the potential impact on calf and hay production costs of different levels of hay spoilage using square and round hay-baling methods. Since spoilage differences between alternative hay-baling methods were not measured, we evaluated cost impacts at different spoilage levels. The results are illustrated in Figures 2 to 5. Only the values pertaining to meadow management systems using tall fescue are shown and discussed, since

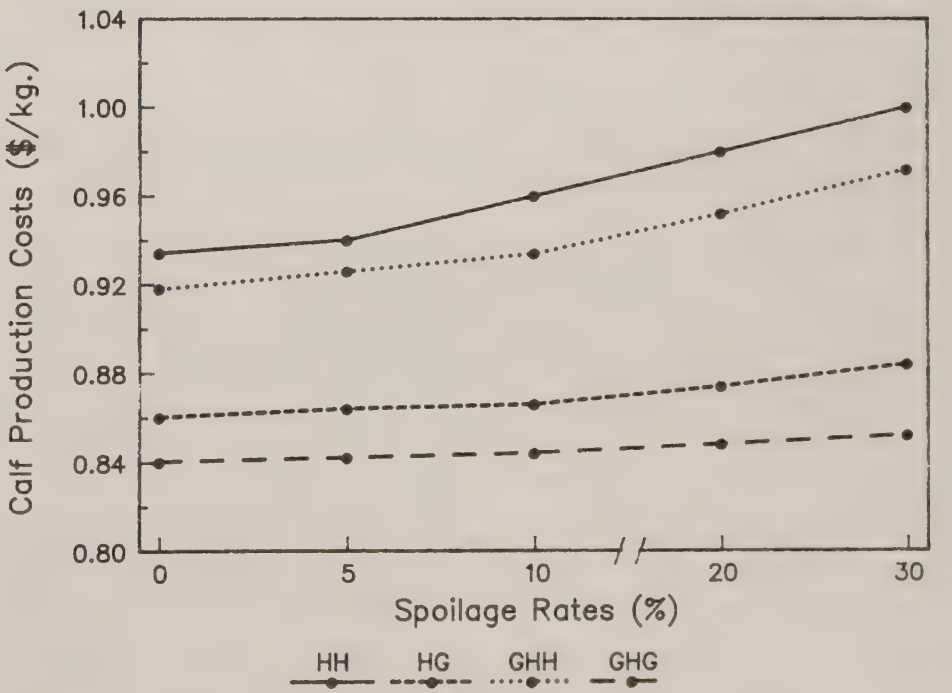



Figure 3. Impact of different levels of hay spoilage on variable calf production costs for alternative meadow management systems using tall fescue and round bales, West Virginia, 1986.

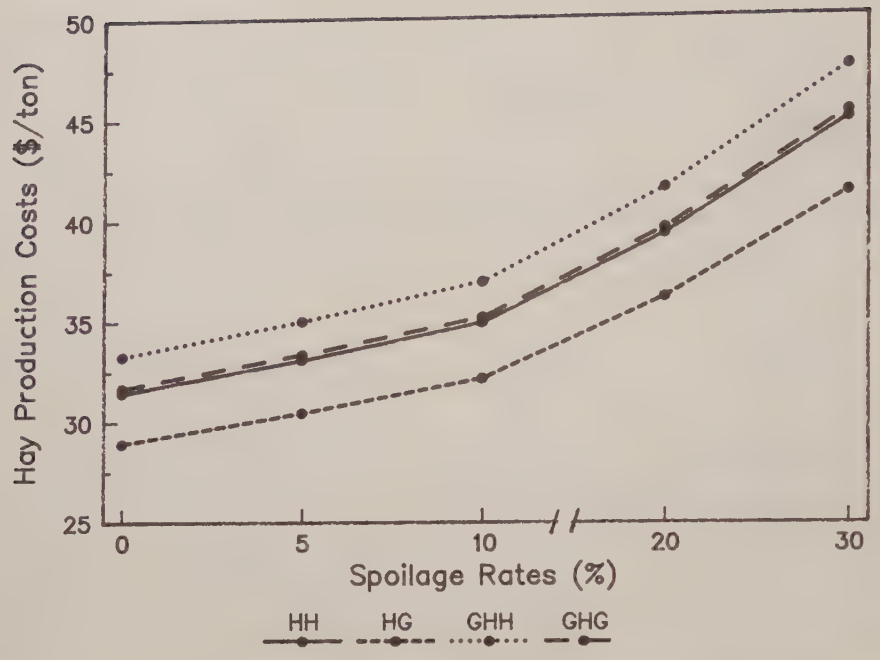



Figure 4. Impact of different levels of hay spoilage on variable hay production costs for alternative meadow management systems using tall fescue and square bales, West Virginia, 1986.

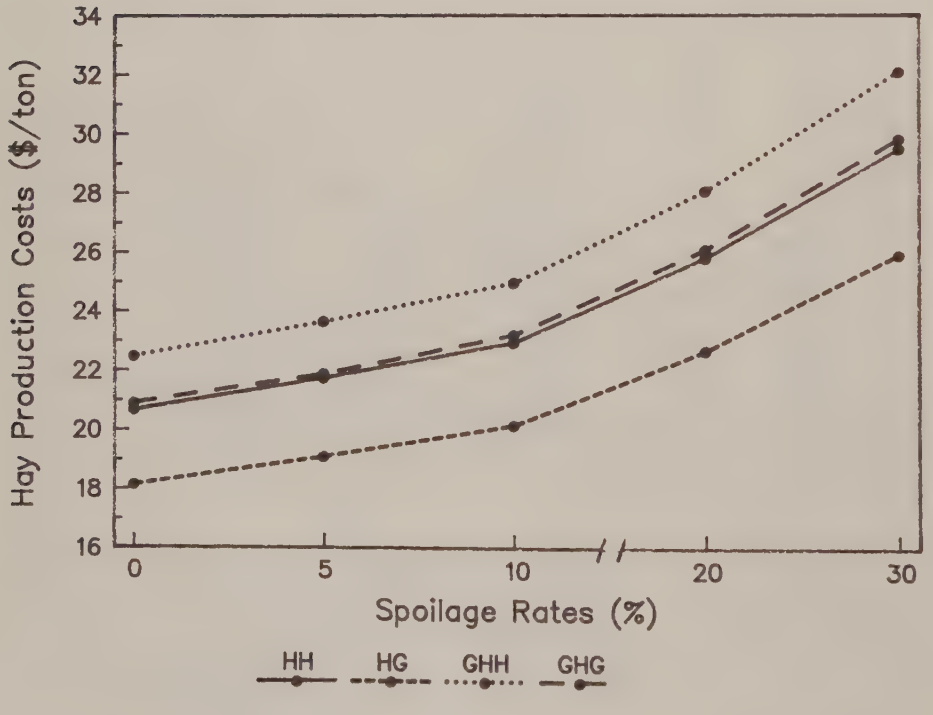



Figure 5. Impact of different levels of hay spoilage on variable hay production costs for alternative meadow management systems using tall fescue and round bales, West Virginia, 1986.

the same general relationships hold f the systems using orchard grass.

Calf and hay production costs are d rectly proportional to the amount spoilage regardless of the hay-balir method. Again, system GHG's low calf production costs and HG's low hay production costs are obvious fro these illustrations. Less apparent is t absolute production cost superiority the round-baling method. For instanc costs of round baling for a given syste at the highest spoilage level evaluate (30 percent) were always lower tha those for the square-baling method f the same system with no spoilage los Therefore, in this analysis, these resul show that round baling is more econom cal than square baling. It would als seem that, in systems with lower "need for hay (HG and GHG), calf productio costs are little influenced by spoilage lo (Figures 2 and 3). Further research needed to quantify the physical and co differences in spoilage between alterna tive hay-baling methods.

## Decision-making implications

Although the absolute, and in som cases the relative, profit values wi change in response to changing physica conditions, prices, and costs, our find ings have implications for producer dec sion making. They indicate that certai extended grazing systems are among th low-input systems that can reduce pro duction costs and enhance profits com pared to conventional systems that d not include early or late grazing. Whe combined with other production an management practices, it is possible tha profits can be further increased. For ex ample, D'Souza et al. (1988) show tha grazing systems incorporating warm season grasses can increase profits fro beef cattle production, especially in tem perate, hill-land areas. Thus it is qui possible that a cow/calf production sy tem incorporating both extended grazin and warm-season grasses, among oth innovative approaches, can realize si able increases in profit and possibly als in environmental quality. This is an are needing further research.

## Conclusions

We have examined the farm-level impacts of extended grazing on production costs and profitability of cow/calf production. Alternative meadow management systems and grasses were analyzed using a combination of primary and secondary data and an economic engineering approach. The analysis showed that extended grazing can be a more profitable option for cow/calf production.

However, since costs, prices, weather, and other conditions vary, the relative profitability of alternative production systems also varies. On one hand, flexibility to shift among management alternatives, depending on relative costs and prices, could enhance long-term profitability for producers willing to change their operating strategy. On the other hand, the biological constraints associated with agricultural production could make it difficult for producers to adjust input and output levels rapidly in response to changes in price and other variables. Furthermore, the timeliness of labor and equipment use should be considered, since haying and grazing have different labor demands that may affect their suitability for different farming systems. Flexibility to shift among systems is not easily captured in models, including LP. To the extent that it is omitted, an analysis based on LP has limitations. Still, it can provide useful information on allocation of constrained resources to guide decision making, as is demonstrated here. This information should be viewed in the context of the mechanism used to generate it: it is subject to modification when conditions change and new information becomes available.

This analysis reveals that GHG, a system involving early spring grazing, one hay cutting, and late fall grazing, is the optimal extended grazing system for cow/calf production. Furthermore, tall fescue was found generally to perform better than orchard grass with respect to production, cost, and profitability criteria. Although this study is based on West Virginia data, the results have implications for cow/calf production in other hill-land areas. In addition, similar types of analyses can be used to evaluate other low-input systems or practices.

Incorporating extended grazing or other innovative grazing methods into the farm plans of cow/calf producers may not be a panacea for the low and often times negative net returns characterizing many such operations. However, the potential for reducing wintering costs and increasing profits does exist--a potential that can be further magnified if complementary innovations besides extended grazing are also incorporated into the farm system. To the extent that such innovations are environmentally sound, the potential for maintaining or increasing environmental quality can be realized together with increased profits.

**Acknowledgments.** The helpful review comments of Alan Collins, Jerry Fletcher, Tim Phipps, and two anonymous journal reviewers on earlier drafts are gratefully acknowledged.

### References

1. Baker, B. S., P. E. Lewis, D. K. Colyer, F. E. Woodson, K. E. Inskeep, and R. H. Maxwell. 1981. 1970-1979 Allegheny Highlands project report. West Virginia Agric. and For. Exp. Stn., Morgantown, West Virginia. pp. 10-14.
2. Baker, B. S., and R. L. Nestor. 1979. Forage and weed species and grazing management systems on permanent pastures in the Allegheny Highlands of West Virginia. Bulletin 670. West Virginia Agric. and For. Exp. Stn., Morgantown, West Virginia.
3. Baker, M. J., E. C. Prigge, and W. B. Bryan. 1988. Herbage production from hay fields grazed by cattle in fall and spring. J. Prod. Agric. 1:273-279.
4. D'Souza, G. E., R. F. Romero, and D. K. Smith. 1988. The investment potential of warm-season grasses for hill-land beef producers. Northeastern J. Agric. and Res. Econ. 17:56-63.
5. Eagan, G. V. 1986. Custom machinery rates guide for 1986-87. Report FS 805. West Virginia Coop. Ext. Service, Morgantown, West Virginia. pp. 1-2.
6. Layton, R. A., A. L. Barr, and P. E. Nesselroad. 1970. Estimated annual costs, production and income for selected livestock and crop enterprises. Eastern West Virginia. Bull. 594T. West Virginia Agric. and For. Exp. Stn., Morgantown, West Virginia.
7. Maxwell, E. W. 1988. An economic analysis of alternative meadow management systems for West Virginia beef cow/calf producers. M.S. thesis. West Virginia Univ., Morgantown, West Virginia.
8. National Research Council. 1976. Nutrient Requirements of Beef Cattle. 5th ed. National Academy of Sciences, National Research Council, Washington, DC.
9. West Virginia Department of Agriculture. 1986. Agricultural Statistics. West Virginia Crop Rep. Serv., Charleston, West Virginia.
10. Wilman, D., and P. D. Griffiths. 1978. The effect of winter and early spring grazing by sheep on subsequent sward production. J. Agric. Sci. 90:471.

***Rockefeller Foundation environmental research fellowships in international agriculture***

These research fellowships provide an opportunity for established environmental scientists to join multidisciplinary research teams at international agricultural research centers such as IRRI, CIMMYT, CIAT, IITA, ICRISAT, CIP, and AVRDC. The objective is to encourage creative and imaginative research aimed at integrating environmental and natural resource protection with mainline international agricultural research and development. The fellowships provide 1-2 years' residency at the host center plus research support with funding shared between the Foundation and the center.

Natural scientists and engineers from all parts of the globe having expertise and an established record of research productivity are eligible to apply. Applicants must qualify for an appointment of visiting scientist at the host center, and a written project proposal needs to be developed and submitted jointly with the center.

For a full description of the program and application requirements, write to: Environmental Research Fellowships in International Agriculture, Agricultural Sciences Division, The Rockefeller Foundation, 1133 Avenue of the Americas, New York, New York 10036.

# Ground water contamination from agricultural sources: Implications for voluntary policy adherence from Iowa and Virginia farmers' attitudes

John M. Halstead, Steven Padgitt, and Sandra S. Batie

Abstract. *Contamination of ground water from agricultural sources has been documented in a majority of the contiguous United States. In this study, we examine the potential for voluntary adoption of management practices that reduce risk of ground water contamination and discuss how farm operators' attitudes regarding the environment might affect the success of voluntary programs. Farmers' behavior and attitudes in Rockingham County, Virginia, and Big Spring Basin, Iowa, reveal that both groups consider the ground water issue to be a serious problem to which they are contributing. This awareness is a significant first step in prompting consideration of management practices that reduce the threat to ground water quality. We also found that the "worst offenders"--that is, farmers applying nitrogen well above agronomic recommendations--were those with the least concern about the problem. If major shifts in farming practices are to occur voluntarily, major incentives or disincentives are needed. Even though the concern about ground water quality is high, the documented risks perceived by farmers are not strongly convincing. The economic incentives for change are questionable at best. Voluntary adoption of best management practices is only one of several policy options. Ultimately, policies designed to reduce ground water contamination may need a mix of strategies, including economic incentives and disincentives, zoning and land use restrictions, environmental regulations, and bans on agricultural chemicals.*

Key words: ground water, public opinion, policy, nitrates, pesticides

## Introduction

The importance of ground water both for drinking water supplies and for irrigation has been well established (Pye and Patrick, 1983). Ground water accounts for 95 percent of U.S. fresh water reserves (Anderson et al., 1985). While much of this resource remains untapped, ground water currently supplies about 50 percent of drinking water and 40 percent of irrigation needs and is the major drinking water source for 85 percent of the rural population (Saliba, 1985). Protection of ground water quality is thus of prime importance to the agricultural sector and many rural communities. Unfortunately, there is growing evidence that ground water is becoming contaminated. Furthermore, eliminating this contamination is more difficult than for surface water. Although ground water is dynamic and eventually is recharged, th time required varies from a few week to several centuries. Decomposition many compounds is slower in groun water than in surface water beause cool temperatures and darkness.

The public generally realizes th ground water needs proper managemen but there is little agreement beyond tha Controversies emerge over the nature the problem, the level of environment and health risks, and the policies mo appropriate to address the problem.

Farmers are caught in a dilemm Their own source of drinking water more likely to be ground water than true for city residents. Rural water sup plies often come from private wells tha have fewer physical safeguards and tha are less likely to be routinely tested fo contamination. On the other hand, pol cies restricting the use of nitrates or pe ticides could reduce farmers' profits.

In this article, we explore responses farmers to ground water issues, drawin upon studies in Virginia and Iowa. W begin with an overview of the issue, i cluding a short discussion of some ma agement issues. We then describe the tw studies and present their results. We co clude with a discussion of policy implic tions for protecting ground water fro agricultural contamination.

## Background

Protecting ground water from co tamination from agricultural sources very difficult. Agricultural wastes th can adversely affect ground water qua

John M. Halstead is Assistant Professor of Resource Economics and Development, University of New Hampshire, Durham, NH 03824-3589. Steven Padgitt is Associate Professor of Rural Sociology, Iowa State University, Ames, IA 50011. Sandra S. Batie is Professor of Agricultural Economics, Virginia Polytechnic Institute and State University, Blacksburg, VA 24060.

All opinions expressed are those of the authors and do not necessarily reflect the views of the funding agencies, nor should an endorsement by the Federal government be assumed. Scientific Contribution Number 1677 from the New Hampshire Agricultural Experiment Station.

ity stem from three primary sources: feed lots, fertilizer use, and pesticide application. Contamination of ground water from routine use of agricultural pesticides or nitrates has been documented in 36 states (O'Hare et al., 1985; Cohen et al., 1984).

Since it is nonpoint in nature, it often is difficult or expensive to identify, monitor, and manage sources of contamination. Also, maximum acceptable contaminant levels for pesticides in ground water have been established only for a few pesticides, and health effects of agricultural chemicals have not been well documented. However, despite the lack of conclusive evidence, many pesticides are known or suspected carcinogens, mutagens, teratogens, and central nervous system depressants (Hallenbeck and Cunningham-Burns, 1985), and nitrate ingestion is well known to cause methemoglobinemia, or blue baby syndrome (Busch and Meyer, 1982). Finally, the extent of contamination is largely determined by random variables, such as weather; and the physical and economic tools for measuring, monitoring, and managing this type of nonpoint source pollution are not well developed.

Several strategies have been proposed for managing nonpoint source pollution: standards, such as an upper limit on allowed contaminant loadings; economic incentives applied to farm management strategies, such as taxes on pesticides or cost sharing for improved nutrient and pesticide management; economic incentives applied to estimated contaminant loading, such as taxes on soil loss; farm management practice standards, such as required use of certain best management practices; and delineation of property rights for ground water so that polluters of ground water would be liable for damages to other parties (Halstead and Zhu, 1987).

It may be possible to get farmers to change their application rates and practices voluntarily, without resorting to regulatory options. Farmers dislike regulation and choose farming as an occupation in part because of the freedom it offers (Hoiberg and Bultena, 1981; Gully, 1974). However, the protection of this freedom may require voluntary acceptance of responsibility for nonpoint pollution. Farmers' attitudes clearly are important in determining the success of voluntary programs.

The freedoms that farmers have enjoyed in the past may not be the pattern of the future, however. One example is the change in farming patterns on potentially erosive land. Although participation in government farm programs remains voluntary, most grain farmers participate because the price supports are an economic necessity. The 1985 Farm Security Act makes program benefits conditional on protecting highly erosive land. This "conservation compliance" provision comes after more than 50 years of technical development, support, and educational efforts to control soil erosion. These voluntary incentives of the past have not been sufficient to curb soil erosion to acceptable levels.

Similarly, if routine use of agricultural chemicals is judged to be a threat to ground water quality, then the time for voluntary response could be relatively short. The success of mandatory programs also depends on farmers' attitudes, but less so than with voluntary programs. Policy objectives that farmers support will probably be less expensive and are more likely to be implemented successfully.

## Methods

For effective policy design, it is important for policymakers to gauge farmers' opinions on key current environmental and economic issues in agriculture. We conducted studies to estimate attitudinal responses and farm management practices in the Big Spring Basin area of northeastern Iowa in 1986 (Padgitt, 1987) and Rockingham County, Virginia, in 1987 (Halstead, et al., 1988). These two areas have several similarities:

-the main agricultural enterprises in both areas are corn production and intensive livestock (primarily dairy);

-agriculture is a major component of both regions' economies;

-both areas are underlain by karst hydrologic systems that are highly susceptible to ground water contamination;

-both areas have a history of agriculturally related ground water problems.

Of course, many agricultural regions in the U.S. are in karst areas (Hallberg, 1987), and many share these other similarities. Given the general resemblance between Rockingham County and Big Spring Basin, the next questions of interest are: What similarities exist between Iowa and Virginia farm management practices? How do attitudes toward agriculture, the environment, and ground water quality differ? How are these attitudes and beliefs translated into actual behavior? If attitudes and beliefs between the two study areas are similar, and if attitudes and actions are indeed related, it may be possible to generalize the results of this study to other areas.

In Iowa, 229 dairy and grain farmers were contacted by mail questionnaire and personal interview, for a response rate of 89 percent. The Iowa survey was a census of all active farm operators in the basin. In Rockingham County, Virginia, all 291 Grade A dairy operations in the county were surveyed via a mail questionnaire. We used Dillman's Total Design Method (Dillman, 1978) and got a response of 50.5 percent. The surveys included questions designed to identify the respondent's attitudes on economic and environmental issues related to agriculture in the respondent's county, the state, and in the nation as a whole. The two surveys, although initially constructed for separate projects, were nearly identical in question content and format.

In both surveys, respondents were asked four questions, with a total of 28 parts, that dealt with the importance of various economic and environmental issues. These questions divide into three categories: economic concerns, environmental issues, and economic-environmental tradeoffs.

## Results

### Economic issues

Regarding six state-level "issues of concern" (Table 1), about three-fourths of Virginia respondents and two-thirds to three-fourths of the Iowa respondents attached highest priority ratings to protecting water quality, preventing soil erosion, and attaining profitability in

agriculture. In contrast, far fewer (only 37 percent in Virginia and 41 percent in Iowa) placed highest priority on maintaining economic viability of rural communities. In both studies, only one in five respondents placed highest priority on diversifying their state's agriculture. Among the Virginia dairy farmers, fewer than 5 percent thought that attracting industry to Virginia should be of highest priority. This contrasts with 22 percent of the respondents making the same assessment for Iowa (an additional 23 percent thought that attracting industry was of high, but not highest, priority), which makes this the only item of six where meaningful differences were found between Iowa and Virginia respondents. (In the questions in Table 1, items were identical between the two studies, but the response categories were not. The Virginia study used a 4-point scale, and the Iowa study used a 5-point scale. Thus, percentage responses for each point on the scale are not directly comparable.) These answers show the relative importance of economic prosperity and maintaining environmental quality for the responding farmers. Specifically, they attached lower priority to economic development and agricultural diversification than to water quality and soil erosion.

Table 1. Priority Ratings of Six Issues of Concern in Agriculture by Farm Operators in Rockingham County, Virginia and Big Spring Basin, Iowa

| | Rockingham County, VA Rating[a] | | | | |
|---|---|---|---|---|---|
| | Low Priority | | High Priority | | Ratin |
| | 1 | 2 | 3 | 4 | Avg |
| | (percentages of respondents) | | | | |
| Profitability in agriculture (n = 133) | 0.0 | 4.2 | 14.9 | 74.3 | 3.7 |
| Protecting water quality (n = 135) | 1.5 | 2.2 | 20.0 | 76.3 | 3.7 |
| Preventing soil erosion (n = 135) | 0.7 | 1.5 | 23.0 | 74.8 | 3.7 |
| Maintaining viability of rural communities (n = 123) | 4.1 | 16.3 | 42.3 | 37.4 | 3.1 |
| Diversifying agriculture in Virginia (n = 123) | 13.8 | 26.8 | 39.0 | 20.3 | 2.7 |
| Attracting industry to Virginia (n = 130) | 62.3 | 26.2 | 6.9 | 4.7 | 1.5 |

| | Big Spring Basin, IA Rating[a] | | | | | |
|---|---|---|---|---|---|---|
| | Low Priority | | | High Priority | | Ratin |
| | 1 | 2 | 3 | 4 | 5 | Avg |
| | (percentages of respondents) | | | | | |
| Profitability in agriculture (n = 205) | 0.9 | 3.4 | 4.9 | 16.1 | 74.6 | 4.6 |
| Protecting water quality (n = 210) | 0.0 | 1.9 | 6.7 | 24.8 | 66.7 | 4.5 |
| Preventing soil erosion (n = 208) | 0.0 | 1.0 | 7.2 | 25.0 | 66.8 | 4.5 |
| Maintaining viability of rural communities (n = 204) | 0.0 | 3.9 | 18.1 | 37.3 | 40.7 | 4.1 |
| Diversifying agriculture in Iowa (n = 203) | 4.4 | 11.3 | 34.5 | 30.5 | 19.2 | 3.4 |
| Attracting industry to Iowa (n = 204) | 6.9 | 10.3 | 38.2 | 23.0 | 21.6 | 3.4 |

[a] Rating scales not identical between the two studies.

### *Environmental issues*

Ground water contamination in both Rockingham County and Big Spring Basin has not been fully ascertained. However, it is known that in Rockingham County about 12 percent of the farms have some nitrate problem. In Big Spring Basin, about one-third of the wells have nitrate levels exceeding EPA's 45 milligrams per liter nitrate standard. In addition, five different agricultural pesticides have been found in water samples from ground water in Big Spring Basin (Cohen et al., 1984). Media coverage of contamination has affected farmer perceptions about pollution and ground water management.

Respondents were asked their concerns about health risks associated with water quality at four sites--in the nation, in their states and counties, and on their own farms. In both states they were more

Table 2. Levels of Concern Regarding Agricultural Chemical Risks to Human Health Among Rockingham County, Virginia, Dairy Farmers and Big Spring Basin, Iowa, Farm Operators

| | LEVEL OF CONCERN (percentage) | | | | | |
|---|---|---|---|---|---|---|
| | Not At All | Somewhat | Very | Not Sure | Chi-squared[a] | t-statistic[b] |
| In nation as a whole | | | | | | |
| Virginia (n = 130) | 0.8 | 46.1 | 46.9 | 6.2 | 1.740 | 1.75* |
| Iowa (n = 167) | 1.2 | 46.1 | 49.1 | 3.6 | | 5.33*** |
| In my state | | | | | | |
| Virginia (n = 130) | 0.8 | 43.1 | 52.3 | 3.8 | 9.667** | 0.56 |
| Iowa (n = 167) | 0.6 | 34.7 | 64.7 | 0.0 | | 2.23** |
| In my county | | | | | | |
| Virginia (n = 130) | 0.8 | 39.2 | 56.9 | 3.1 | 11.075** | −0.64 |
| Iowa (n = 167) | 0.5 | 24.6 | 74.3 | 0.6 | | −1.51 |
| On my own farm | | | | | | |
| Virginia (n = 130) | 3.1 | 36.2 | 56.2 | 4.6 | 9.324** | — |
| Iowa (n = 167) | 1.8 | 25.2 | 71.3 | 1.8 | | — |

* Significant at .10 level.
** Significant at .05 level.
*** Significant at .01 level.
[a] Test is for independence of distribution between Iowa and Virginia studies.
[b] Test is for same sample comparison between "in nation as a whole," "in my state," and "in my county" vs. "on my own farm."

concerned about water quality in their own counties and on their own farms than for the nation as a whole (Table 2).

No difference was found between the two studies for the nationwide assessment, but significant differences in distributions (Chi Squared test, $P < .05$) were found for state, county, and own farm assessments (Table 2). In these three, the level of concern was higher in the Iowa sample. For example, 71 percent of Iowa respondents said they were "very concerned" about the problem on their own farms, while 56 percent answered similarly in the Virginia study. Although farm operator concerns were relatively high in both states, these are perceptual indicators and may not correlate with objective conditions.

For their implications for voluntary policy, the pattern among the four levels is more important than the differences between the two samples. Before voluntary change is likely to occur, farmers need to be convinced of the need to change. Often behavior change is inhibited when persons deny or displace existence of a problem. Acknowledging that the health risk on one's own farm is at least as great as at other locations would lead farmers to reassess existing practices. This acknowledgment did prevail in both the Iowa and Virginia samples.

Based on paired t-tests for the Iowa study, concern about one's own farm did not differ from the county level, and concerns about one's own farm were higher than for statewide and nationwide problems. The Virginia study showed significantly greater concern for agricultural chemical risks to human health at the farm level than at the national level.

### *Economic-environmental tradeoffs*

Fourteen questions were concerned with specific tradeoffs between ground water, environmental quality, and agricultural chemical use. These questions revealed that a large majority of farmers were concerned with the potential effects of chemicals on ground water in their area and believed that more research and possibly stricter regulation on these chemicals were needed (Table 3). Responses between the two studies were remarkably similar. For 10 to 13 compara-

Table 3. Respondents' Attitudes Regarding Economic-Environmental Tradeoffs[a]

| | Rockingham County, VA | Big Spring Basin, IA | t-statistic |
|---|---|---|---|
| **"Satisfied with Current Situation" Questions** | | | |
| I am confident that agricultural pesticides if used as directed are not a threat to the environment. | | | |
| Mean | 2.71 | 2.45 | 2.29* |
| Standard Deviation | 0.98 | 0.92 | |
| n | 133 | 170 | |
| Should ground water supplies become contaminated, I am confident scientists will develop ways to purify them. | | | |
| Mean | 2.30 | 2.09 | 1.83 |
| Standard Deviation | 0.86 | 0.91 | |
| n | 128 | 117 | |
| So little pesticide residue ever enters the ground water it could never pose a health problem. | | | |
| Mean | 1.71 | 1.52 | 1.91 |
| Standard Deviation | 0.77 | 0.61 | |
| n | 132 | 155 | |
| Instead of worrying about the effects of pesticides we should spend more time and effort in solving other problems in farming. | | | |
| Mean | 2.03 | 2.07 | 0.36 |
| Standard Deviation | 0.79 | 0.82 | |
| n | 133 | 136 | |
| Water quality is more an issue for the future—today the threat from agricultural chemicals is quite small. | | | |
| Mean | 1.99 | 1.86 | 0.97 |
| Standard Deviation | 0.83 | 0.81 | |
| n | 135 | 145 | |
| Pollution control requirements have gone too far, they already cost more than they are worth. | | | |
| Mean | 2.24 | 1.90 | 2.87** |
| Standard Deviation | 0.81 | 0.87 | |
| n | 120 | 122 | |
| We must relax environmental standards in order to achieve economic growth. | | | |
| Mean | 1.79 | 1.77 | 0.19 |
| Standard Deviation | 0.75 | 0.70 | |
| n | 121 | 133 | |
| We already have too much regulation on the use of agricultural pesticides. | | | |
| Mean | 2.08 | 1.92 | 1.45 |
| Standard Deviation | 0.81 | 0.77 | |
| n | 131 | 131 | |
| Too much money is being spent in (Rockingham County) (Big Spring Basin) to study agricultural residue in groundwater. | | | |
| Mean | 2.11 | 1.66 | 4.79** |
| Standard Deviation | 0.75 | 0.78 | |
| n | 114 | 119 | |

*(Continued)*

Table 3. Respondents' Attitudes Regarding Economic-Environmental Tradeoffs[a]—*(Continued)*

| | Rockingham County, VA | Big Spring Basin, IA | t-statistic |
|---|---|---|---|
| **"Concerned with Current Situation" Questions** | | | |
| We cannot be too careful when it comes to putting new pesticides on the market. | | | |
| Mean | 3.69 | 3.49 | 2.11* |
| Standard Deviation | 0.57 | 0.75 | |
| n | 134 | 162 | |
| I worry about the purity of drinking water in (Rockingham County) (Big Spring Basin). | | | |
| Mean | 3.20 | 3.38 | 1.70 |
| Standard Deviation | 0.87 | 0.68 | |
| n | 129 | 153 | |
| Protecting the environment is so important that the requirements cannot be too high, and continuing improvements must be made regardless of costs. | | | |
| Mean | 2.73 | 2.70 | 0.26 |
| Standard Deviation | 0.86 | 0.89 | |
| n | 123 | 142 | |
| We must accept a slower economic growth in order to protect the environment. | | | |
| Mean | 2.98 | 2.64 | 2.83** |
| Standard Deviation | 0.87 | 0.92 | |
| n | 124 | 126 | |
| Agriculture should be allowed to expand, but in a way that will cause minimal damage to the environment.[b] | | | |
| Mean | 3.61 | | |
| Standard Deviation | 0.63 | | |
| n | 124 | | |

* Significant at .05 level, two-tail test.
** Significant at .01 level, two-tail test.
[a] Four point Likert scale, 4 = tend to agree, 1 = strongly disagree
[b] Question not asked in Big Spring Basin survey

ble items, no significant difference was found between Virginia and Iowa respondents' answers.

Questions that involved tradeoffs between economic and environmental quality issues fell into two categories: those reflecting satisfaction with available technologies and agricultural input use, and those dealing with the need for change (Table 3). These two categories were labeled "satisfied (with current situation)" and "concerned (about current situation)," respectively.

Only one of the satisfied statements--"I am confident that agricultural pesticides, if used as directed, are not a threat to the environment"--approached a majority of agreement responses, as measured by summing the two levels of agreement. Fifty-four percent of Virginia farmers and 49 percent of Iowa farmers agreed with this statement. None of the remaining statements of satisfaction received agreement ratings greater than 40 percent. In contrast, between 55 percent and 95 percent of the respondents agreed with the statements in the "concerned" category. In general, respondents from the two states had similar responses to these questions.

The results of the attitudinal survey indicate a high level of concern regarding agricultural chemicals and water quality. Respondents were found to consistently disagree with the position tha degradation of ground water and the en vironment was an acceptable tradeoff fo improved profitability.

## *Relation of responses to rates of nitrogen applicatio*

The attitudinal questions provide use ful information on general environmen tal attitudes of farmers in the two state as well as on responses that might b expected to policy initiatives. It is in structive to examine how these attitude are related to actual farming practices

For example, we identified "high" an "low" fertilizer appliers in both studie The underlying rationale for dividing th samples into these groups was to com pare attitudes of those farmers applyin more N than is agronomically recom mended to those more closely followin recommended application rates. A com mon problem in livestock-intensive re gions is the failure of farmers to tak credit for the nitrogen supplied by ma nure applications (Swartz, 1987; Kaap 1986), so that the total application o available N from commercial fertilize and manure exceeds agronomic recom mendations. Much of the nitrogen fro manure is released over several years Therefore, repeated annual application of manure can lead to residual nitroge in the soil that is available for plan growth (Gilbertson, 1979); disregardin this residual nitrogen also leads to agro nomically excessive levels of N applica tion.

Because management data were no identical between the studies, differen procedures were followed to define thes groups. In the Virginia study, the initia assumption was that an adequate annua application of plant-available N to cor should total 109 kg/ha, based on nutr ent management plans devised for th county (Givens, 1987). Virginia farme applying more than 109 kg/ha of avai able N were identified as comprising tw subsets. The first subset was compose of those farmers who had four or si months manure storage and applied a least 109 kg/ha of commercial N to the corn, taking no credit for manure N Thirty-four farmers were in this grou

applying an average annual rate of 125.2 kg/ha of commercial N to 1,201 ha. The second subset was composed of those farmers with no storage who applied at least 120 kg/ha of commercial N. For both subsets, more N was being provided (either in manure or commercial form) than could be used by the crops. This second subset had 15 farmers applying an average annual rate of 152.9 kg/ha of N to 356 ha. These two groups of "high appliers" included about one-third of both large farms (greater than 42 ha) and small farms (less than 42 ha). Thus high application rates appear to be unrelated to farm size.

The "low applier" group was composed of 51 farmers. "Low appliers" with four to six month manure storage applied 68.2 kg/ha of commercial N to a total of 826.7 ha. "Low appliers" with no manure storage applied, on average, 64.3 kg/ha of N to 561.2 ha. The two groups ("high and low appliers") accounted for 2,984 ha, or about 66.3 percent of total county corn land. Insufficient information on nutrient management practices was available to classify the remaining 35 farmers in the Virginia sample as either high or low appliers.

In the Iowa Big Spring Basin study, the procedure to identify "high" and "low" applier groups was based on whether available N on corn land from commercial fertilizer and manure was estimated to exceed or fall below 174.6 kg/ha. This criterion was based on an average corn yield of 8,196 kg/ha and an Iowa State University recommendation of 2.2 kg of N per 100 kg (1.2 lb. per bushel) of harvested grain. The manure estimate assumed that .4 kg of N is produced per day per 1,000 kg of animal weight. It took into consideration animals held in confinement and assumed that one-half of the N generated would probably volatilize or otherwise be lost, but one-half could be available as a plant nutrient. We identified 55 percent of the Iowa sample as "low appliers" and 45 percent as "high appliers." On average, the amount of available N per corn crop land hectare for the "low applier" group was 138.5 kg. For the "high applier" group, N availability was 232.4 kg/ha for corn. Corn crop land averaged 53.7 ha for the "low applier" group and 74.2 ha for the "high applier" group.

We compiled a profile of attitudinal characteristics to determine whether there were substantial differences between attitudes of these two groups. T-tests were calculated between mean response values of the "high appliers" and the other farmers. In both regions, high appliers were somewhat less concerned than other farmers about ground water contamination on their own farms (Table 4); differences were observed between the two groups' levels of concern about the health effects of agricultural chemicals on ground water in their county, their state, or the nation.

Statistically significant differences were found between "high" and "low" nitrogen appliers in response to five of the fourteen attitudinal questions in the Rockingham County study and three of the five questions in the Big Spring Basin study. These differences are summarized in Table 4.

Where significant differences were found between "high" and "low applier" groups' responses, mean differences ranged from .32 to .59 (on a scale of one to four). These results may not entirely explain why "high appliers" use larger quantities of N than "low appliers," but they suggest that, since these farmers see fewer adverse consequences of contamination, they may have less incentive to moderate their application rates.

## Policy implications

The data from these two studies do not provide a definitive answer to the question of whether voluntary efforts through educational approaches would be sufficient to alleviate the threat of agricultural chemicals to the environment. They do, however, offer some insight.

Both the Virginia and Iowa farmers consider the ground water issue to be serious, and they believe that they are contributing to the problem. Responses to issues of concern differed very little between the two areas, although they are widely separated geographically and probably quite different culturally. These attitudinal similarities may be relevant when considering both voluntary and mandatory policy initiatives over broad areas of the U.S. Widespread awareness of the problem is a significant first step in reducing the threat to ground water quality. Indeed, a "teachable moment" may exist.

The analysis also contains some disturbing findings. The worst offenders--that is, the high appliers--were the ones who were least concerned about the

Table 4. Differences in Responses to Questions from Tables 2 and 3 between High and Low Applier Groups of Nitrogen Fertilizer. Rockingham County, Virginia and Big Spring Basin, Iowa[a]

| Statement | Response |
|---|---|
| Concern over agricultural chemical risks to human health on own farm | High applier group less concerned than low applier group in both Virginia and Iowa |
| I am confident that agricultural pesticides if used as directed are not a threat to the environment. | High applier group more in agreement than low applier group in both Virginia and Iowa |
| Should ground water supplies become contaminated, I am confident scientists will develop ways to purify them. | High applier group more in agreement than low applier group in Iowa |
| Water quality is more an issue for the future—today the threat from agricultural chemicals is quite small. | High applier group more in agreement than low applier group in Iowa |
| We cannot be too careful when it comes to putting new pesticides on the market | High applier group less in agreeement than low applier group in Virginia |
| We already have too much regulation on the use of agricultural pesticides. | High applier group more in agreement than low applier group in Virginia |
| I worry about the purity of drinking water in Rockingham County. | High applier group less in agreement than low applier group in Virginia |
| Protecting the environment is so important that the requirements cannot be too high, and continuing improvements must be made regardless of costs. | High applier group less in agreement than low applier group in Virginia |

[a] Questions for which the high and low applier groups' answers did not differ significantly in either state are not listed.

problem. This attitude was compounded in Big Spring Basin because the high appliers also tended to farm more land.

Although it is unrelated to the empirical component of this paper, another disturbing matter is state-of-the-art best management practices. Unlike alternatives for soil conservation, best management practices to protect ground water are still being developed (CAST, 1985). If a "teachable moment" does exist, it may be hampered by a lack of teaching material. Whether the alternatives under development will be suitable--economically, environmentally, and agronomically--is still unknown. Debate also continues over whether best management practices for soil erosion (that is, conservation tillage or no tillage) increase the threat to ground water (Hallberg, 1986).

However, in some cases there are known alternatives to current practices. For example, in the Big Spring Basin, total N availability exceeded crop requirements by as much as 150 percent in 1984 (Padgitt, 1985). In that setting, educational programs emphasized both economic and environmental advantages in reducing rates of nitrogen fertilizer. In two years, about 40 percent of the farm operators in the basin reduced their fertilizer rates. In aggregate, however, the reduction was only about 25 percent of the amount needed to reach the recommended level of 1.2 pounds per bushel of corn harvested. Educational programs aimed at improving agricultural practices that adversely affect ground water have also been implemented in Wisconsin, Vermont, Virginia, and other parts of Iowa (Holden, 1986; Henderson et al., 1984).

Voluntary management changes needed to correct pesticide contamination of ground water may be more difficult to achieve than the problems associated with nitrogen. Unlike with nitrogen, pesticide applications are usually closer to recommended levels. Pesticides may fail to kill pests if applications are too light, and high rates may actually reduce yields (Osteen and Szmedra, 1989). Thus there are incentives for farmers to stay close to the recommendation. There may be opportunities for reduced herbicide use through "banded" rather than "broadcast" applications, and supplemental cultivation. Insecticide use can be reduced through integrated pest management and crop rotations (Osteen and Szmedra, 1989). However, major reductions in pesticide use will likely involve alternative cropping and farming systems, not just fine tuning of existing practices (OTA, 1990).

If major shifts in farming practices are to occur voluntarily, there need to be major incentives or disincentives. Even though the concern about ground water quality is high, the documented risks are not (Amsden, 1986; OTA, 1990). The economic incentives for change are questionable at best. Higher rates of nitrogen application are relatively cheap insurance for years when rainfall may be high and leaching could reduce crop yields (SriRamaratnam et al., 1987). Furthermore, current farm programs may provide incentives for continued use of chemical inputs (Duffy, 1987).

Voluntary adoption of best management practices is only one of several policy options. Ultimately, policy may need to involve a mix of strategies, including economic incentives and disincentives, zoning and land use restrictions, environmental regulations, and bans on agricultural chemicals (Blodgett, 1987; OTA, 1990).

**Acknowledgments.** The contents of this article were developed, in part, under grants from the following: The Virginia Division of Soil and Water Conservation, Department of Conservation and Historic Resources; the United States Geological Survey, Department of the Interior (under award number 14-08-001-01303); Resources for the Future; the Iowa State Water Resources Research Institute; and the Integrated Farm Management Demonstration Program of the Iowa Energy Management Fund, through the Iowa Department of Agriculture and Land Stewardship.

### References

1. Amsden, T. L. 1986. Agricultural chemicals in ground water--an emerging national concern. In Proceedings of Agricultural Impacts on Ground Water--A Conference. Water Well Journal Publishing Company, Dublin, Ohio.
2. Anderson, G. D., J. J. Opaluch, and W. M. Sullivan. 1985. Nonpoint agricultural pollution: Pesticide contamination of ground water supplies. American Journal of Agricultural Economics 67(5):1238-1243.
3. Blodgett, J. E. 1987. Agrichemicals and groundwater: What do we know? In Agricultural Chemicals and Groundwater Protection: Emerging Management and Policy (Proceedings of a conference). The Freshwater Foundation, St. Paul, Minnesota.
4. Busch, D., and M. Meyer. 1982. A case infantile methemoglobinemia in South D kota. Journal of Environmental Health 44:31 311.
5. CAST (Council for Agricultural Science ar Technology). 1985. Agriculture and grour water quality. Report No. 103. Ames, Iowa
6. Cohen, S. Z., C. Eiden, and M. N. Lorbe 1984. Monitoring ground water for pesticide In W. Garner, R. C. Honeycutt, and H. N Nigg (eds.). Evaluation of Pesticides Ground Water. ACS Symposium Series 31 American Chemical Society, Washington, DC
7. Dillman, D. A. 1978. Mail and Telephone Su veys: The Total Design Method. Wiley, Ne York, New York.
8. Duffy, M. 1987. Impacts of the 1985 Foo Security Act. Unpublished paper. Iowa Sta University Cooperative Extension Servic Ames, Iowa.
9. Gilbertson, C. B. 1979. Animal Waste Utiliz tion on Cropland and Pastureland: A Manu for Evaluating Agronomic and Environment Effects. Utilization Research Report No. U.S. Department of Agriculture, Washingto DC.
10. Givens, F. 1987. Personal communicatio with John M. Halstead. Department of Ag ricultural Engineering, Virginia Polytechn Institute and State University, Blacksbur Virginia.
11. Gully, J. L. 1974. Beliefs and values in Amer can farming. ERS-558, Econ. Res. Serv., U.S Department of Agriculture, Washington, DC
12. Hallberg, G. R. 1986. From hoes to herbicide Journal of Soil and Water Conservatio 41(6):357-364.
13. Hallberg, G. R. 1987. Agricultural chemica in ground water: Extent and implication American Journal of Alternative Agricultur II(1):3-15.
14. Hallenbeck, W. H., and K. M. Cunningham Burns. 1985. Pesticides and Human Health Springer-Verlag, New York, New York.
15. Halstead, J. M., S. S. Batie, R. A. Krame 1988. Agricultural practices and environmen tal attitudes of Rockingham County, Virginia dairy farmers: Results of a survey. SP 88 - Virginia Polytechnic Institute and State Un versity, Blacksburg, Virginia.
16. Halstead, J. M., and M. Zhu. 1987. Managin risk and uncertainty in agricultural nonpoin source contamination of ground wate Sources and--solutions (?). Paper presented a the Northeast Agricultural and Resource Eco nomics Association Meetings, Kingston Rhode Island, June 20-22.
17. Henderson, T. R., J. T. Trauberman, and T Gallagher. 1984. Groundwater: Strategies fo State Action. The Environmental Law Inst tute, Washington, DC.
18. Hoiberg, E. O., and G. L. Bultena. 1981. Farm operator attitudes toward governmenta involvement in agriculture. Rural Sociolog 46(4):381-390.
19. Holden, P. 1986. Pesticides and Ground Wate Quality: Issues and Problems in Four States National Academy Press, Washington, DC.
20. Kaap, J. D. 1986. Implementing best manage ment practices to reduce nitrate levels in north east Iowa groundwater. In Proceedings of Ag ricultural Impacts on Ground Water--A Conference. Water Well Journal Publishin Company, Dublin, Ohio.
21. Office of Technology Assessment (OTA 1990. Beneath the bottom line. Agricultura

approaches to reduce agrichemical contamination of groundwater. OTA-F-417. U.S. Government Printing Office, Washington, DC.
22. O'Hare, M., D. Curry, S. Atkinson, S. Lee, and L. Canter. 1985. Contamination of ground water in the contiguous United States from usage of agricultural chemicals. Environmental and Ground Water Institute, Norman, Oklahoma.
23. Osteen, C. D., and P. I. Szmedra. 1989. Agricultural pesticide use trends and policy issues. Agricultural Economic Report Number 622. Economic Research Service, U.S. Department of Agriculture, Washington, DC.
24. Padgitt, S. 1985. Farming operations and practices in Big Spring Basin. Report No. CRD229. Iowa State University Cooperative Extension Service, Ames, Iowa.
25. Padgitt, S. 1987. Agriculture and groundwater issues in Big Spring Basin and Winneshiek County, Iowa. Report No. CRD229A. Iowa State University Cooperative Extension Service, Ames, Iowa.
26. Pye, V. I., and R. Patrick. 1983. Ground water contamination in the United States. Science 221(August 19):713-718.
27. Saliba, B. C. 1985. Irrigated agriculture and groundwater quality--a framework for policy development. American Journal of Agricultural Economics 67(5):1231-1237.
28. SriRamaratnam, S., D. A. Bessler, M. E. Rister, J. E. Matocha, and J. Novak. 1987. Fertilization under uncertainty: An analysis based on producer yield expectations. American Journal of Agricultural Economics 69(2):349-357.
29. Swartz, P. O. 1987. Nutrients: The missing link. Chesapeake Bay Citizens Report. Winter/Spring:5-7.

## RESOURCES

**1990 Farm Bill Environmental and Consumer Provisions,** a two-volume reference prepared by the Center for Resource Economics, is now available. **Volume I: Statutory Language** (200 pages) excerpts statutory language from the Food, Agriculture, Conservation and Trade Act of 1990 that the Center considers relevant to environmental and consumer issues. **Volume II: Detailed Summary** (120 pages) summarizes these provisions with excerpts of all significant statements made jointly by House-Senate "Managers" in the Conference Report. The two volumes may be ordered from the Center for Resource Economics/Island Press for $24.95 plus tax (if applicable) plus $3.00 postage and handling. Discounts on bulk orders are available. Call toll free 1-800/828-1302.

Ways of overcoming common marketing problems faced by organic farmers are reviewed in **"A Guide to Marketing Organic Produce,"** published by Texas A&M University. Copies are $15.00 from Dr. Charles Hall, Texas Agricultural Extension Service, Department of Agricultural Economics, College Station, TX 77843.

Proceedings from the **1990 Crop Pest Management Update Conference** can be obtained for $5.00 from the Department of Entomology, 210 Plant Industry Building, University of Nebraska, Lincoln, NE 68583-0816, (402) 472-2125.

Two **videotapes** on **insect identification** and **scouting in field crops** and a **pest management training manual** are available for $29.95 plus tax for each tape, or purchased together on one tape for $50.00 plus tax. The training manual is $25.00 plus tax. Orders with check payable to the University of Nebraska-Lincoln should be sent to: Field Scouting, 104 Ag. Comm. Bldg., University of Nebraska, Lincoln, NE 68583-0918, (402) 472-3035.

**Protecting Groundwater from Agricultural Chemicals: Alternative Farming Strategies for Northwest Producers** was published by AERO (Alternative Energy Resources Organization). Copies are available at $4.00 from AERO, 44 N Last Chance Gulch, Helena, MT 59601.

**Beneath the Bottom Line: Agricultural Approaches to Reduce Agricultural Contamination of Groundwater,** 346 pages, is available for $15.00 from the Government Printing Office, Superintendent of Documents, Washington, DC 20402; the stock number is 052-003-01190-5. A 79-page summary is available for $4.00, stock number 052-003-001191-3.

### *Farm profiles invited*

For its new department on alternative agriculture profiles, the AJAA welcomes short articles describing farmers who have adopted interesting alternative practices. The articles should include five elements: a brief description of the farm; the problems that made the farmer look for an alternative approach and the reasons why the alternative seemed plausible; a summary of the basic principles behind the alternative (possibly in a sidebar if it interrupts the flow of text); a discussion of how well the alternative has worked; and a discussion of the applicability of the alternative for other farms. The length should be 1500 to 2000 words.

Submissions must be accompanied by a release, signed by the farmer, giving permission for this material to be published in the *American Journal of Alternative Agriculture.* Vol. 3, No. 4, of the AJAA has a further description of the department (page 188); or query the editor for further information. Send submissions to the Editor, AJAA, 9200 Edmonston Road, Suite 117, Greenbelt, MD 20770.

COMMENTARY

# Rotations: Influence and constraint from commodity programs

Stephen Frerichs

Abstract. *Recent research and debate in sustainable agriculture has focused on the role of commodity programs in shaping rotation decisions. The commodity programs are often cited as obstacles to establishing long-term, diversified rotations. However, predicting which rotations would be practiced in the absence of commodity programs is difficult. How strongly commodity programs influence the rotation decision depends on the size of the economic incentive to participate and the percentage of cropland enrolled in the program. Data from the Agricultural Stabilization and Conservation Service (ASCS) were used to calculate the distribution of the percentage of cropland in corn base for each farm record at ASCS in the Corn Belt and Lake States in 1988. The distribution shows that the level of corn program enrollment varies widely. Many corn base acres are found on farms with high corn base enrollment levels, which potentially constrains the rotation choice. However, enrollment levels in the corn program do appear to allow the option of diversified rotations for many corn base acres in the Corn Belt and Lake States, even during the high corn price support years of the mid to late 1980s.*

Key words: Rotation, commodity programs, sustainable agriculture

## How do commodity programs affect the decision to rotate?

Case studies have demonstrated that rotations used to restore nitrogen and disrupt insect and weed cycles with few or no chemicals can be economically competitive with more chemically demanding, conventional rotations (Goldstein and Young, 1987; Dobbs et al., 1988). These alternative rotations become more attractive when the payments from commodity program support are removed because they involve planting more land to non-supported crops, primarily legume forages. Farmers who wish to plant a non-supported commodity instead of the supported commodity must forego their income from the commodity program. The opportunity cost from lost federal income is cited as an obstacle to establishing long-term, diverse rotations (Goldstein and Young, 1987; Dobbs et al., 1988; National Research Council, 1989). An implication is that "a number of government policies and programs have strongly encouraged farmers to specialize and deterred them from adopting diversified farming practices" (National Research Council, 1989).

There has been little research analyzing how strongly commodity program influence and constrain the decision t rotate. This commentary describes cu rent enrollment levels and estimates th potential constraint from corn progra participation in a rotation decision fo farms in the Corn Belt and Lake State The estimate is of a potential constrain only, because we do not know wha would have been planted without th commodity programs.

## The influence of the commodity programs in the decision to rotate

Commodity price and income pro grams raise the price and lower the ris of supported commodities relative t non-supported crops. Higher relativ prices and lower risk encourage the pro duction of supported crops and favor their choice in a rotation by farmers. Ta ble 1 presents the average support abov the market of selected commodities du ing 1984-1987. Notice that support is no equal among crops, with corn and so

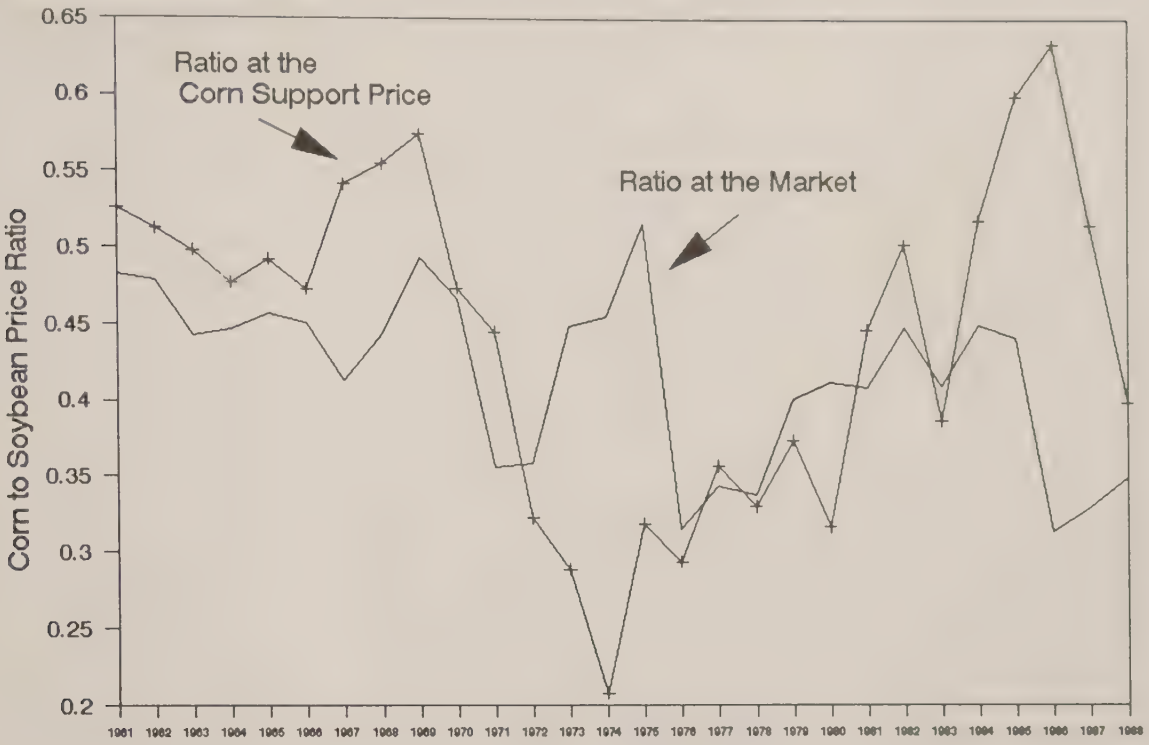
Table 1. Average Support Above Market Prices 1984–1987

| Selected Commodities | Per Acr |
|---|---|
| Corn | $73 |
| Sorghum | $45 |
| Wheat | $27 |
| Barley | $19 |
| Oats | $ 4 |

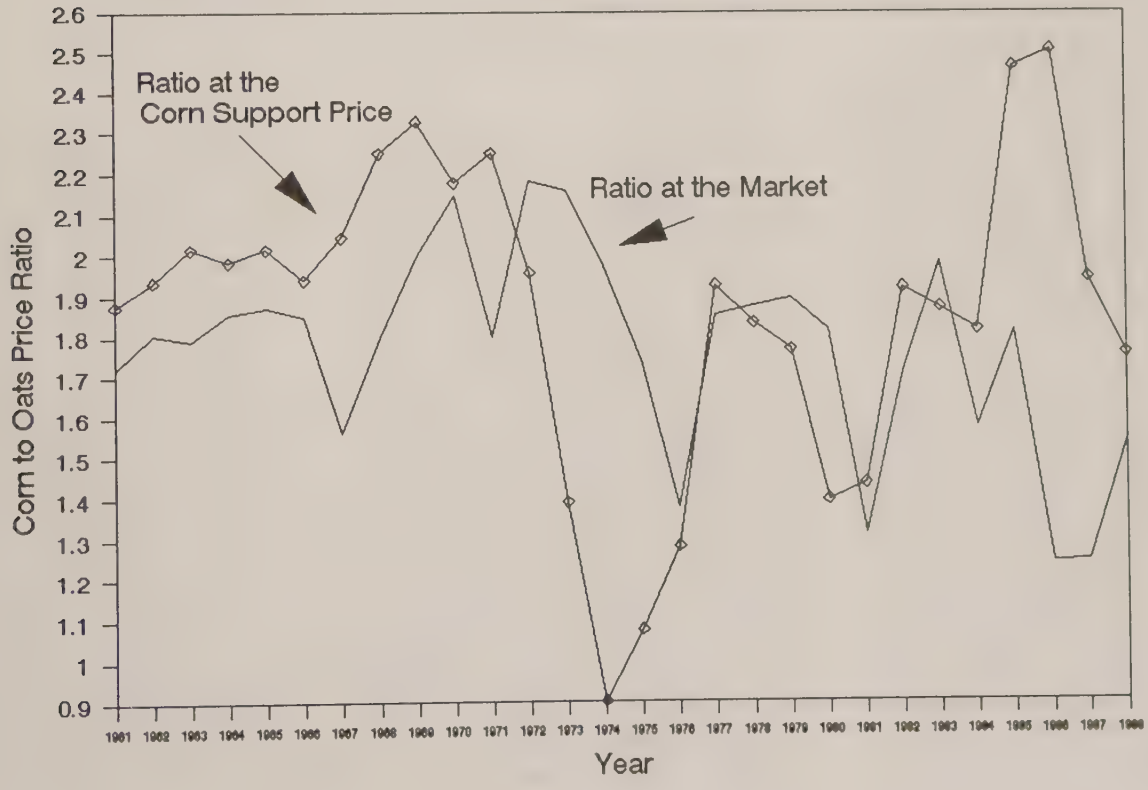
Source: Economic Research Service, U.S. Dept. o Agriculture, 1990

Stephen Frerichs is Examiner, Natural Resource Division, Office of Management and Budget, 725 - 17th Street, NW, Room 8025, Washington, DC 20503. Research for this commentary was conducted while the author was employed at the Economic Research Service, USDA.

Figure 1. Corn—Soybean Price Ratio: At the Market and at the Corn Support Price




Corn—Oats Price Ratio: At the Market and at the Corn Support Price




ghum receiving higher support levels during the 1984-1987 period. Some crops are not supported at all. The crops currently supported with nonrecourse loans include corn, wheat, cotton, rice, sorghum, oats, barley, and soybeans.

Compliance in the corn program increased threefold between 1982 and 1987, mostly due to the agricultural re-

cession of the 1980s and the manner in which the federal government responded with support payments. Because federal support in the 1980s was tied to producing a specific commodity such as corn, the growth in compliance may have translated into a greater influence by the federal government in the crop choice and rotation decision. For example, given the absolute support levels in Table 1, one might expect more corn to be chosen in preference to oats, barley, or wheat, assuming all else remained equal.

Figure 1 shows the relative corn-soybean and corn-oat price ratios since 1961. The price ratios are calculated at market prices and at the support price for corn. The corn support price is not adjusted for any costs imposed by participation and thus overestimates program benefits. Any interaction between announced corn support levels and subsequent average corn market price has been ignored in developing Figure 1.

In the 1960s, participation in the corn program changed the corn-soybean and corn-oat price relationships to favor corn. During the 1970s, corn program compliance was unprofitable and lowered the relative price relationship from market conditions. Figure 1 indicates a favorable change since 1984 in relative prices between corn and soybeans and between corn and oats for corn program participants. The distorted price ratios correspond to high participation rates and the threefold increase in compliance in the corn program in the mid to late 1980s.

The relative level of price support, however, does not capture the potential constraint on rotation choices from commodity program participation. Farmers in the Midwest have several crop alternatives. For example, they could follow a corn-corn-oats-alfalfa rotation, maintain 50 percent of their tillable cropland in the corn program, and reduce intensive agrichemical applications. The potential rotation constraint given participation depends on the level of cropland enrolled in a particular commodity program. The higher the percent enrolled, the more the rotation choice may be constrained and the greater is the opportunity cost of adopting rotations involving non-supported crops.

## *Participation in the corn program as a constraint on the decision to rotate*

Although exceptions exist, to maintain acreage base farmers generally are required to plant the supported crop of the program in which they are enrolled. This may become a constraint on rotation choice when the percentage of the cropland enrolled in a particular commodity program exceeds the amount that is needed for a rotation and that would have been planted without the program. Because of program rules, a two-year corn-soybean rotation is not possible if farmers have 100 percent of their land enrolled in the corn program and want to continue to receive payments every year. Measuring the percentage level of cropland enrollment in a commodity program can be an estimate of the potential rotation constraint. The higher the percentage of a farm's cropland that is enrolled in the commodity programs, the greater the potential constraint on a producer's rotation choice. The estimate is potential by nature because it is not known what would have been planted without the commodity programs.

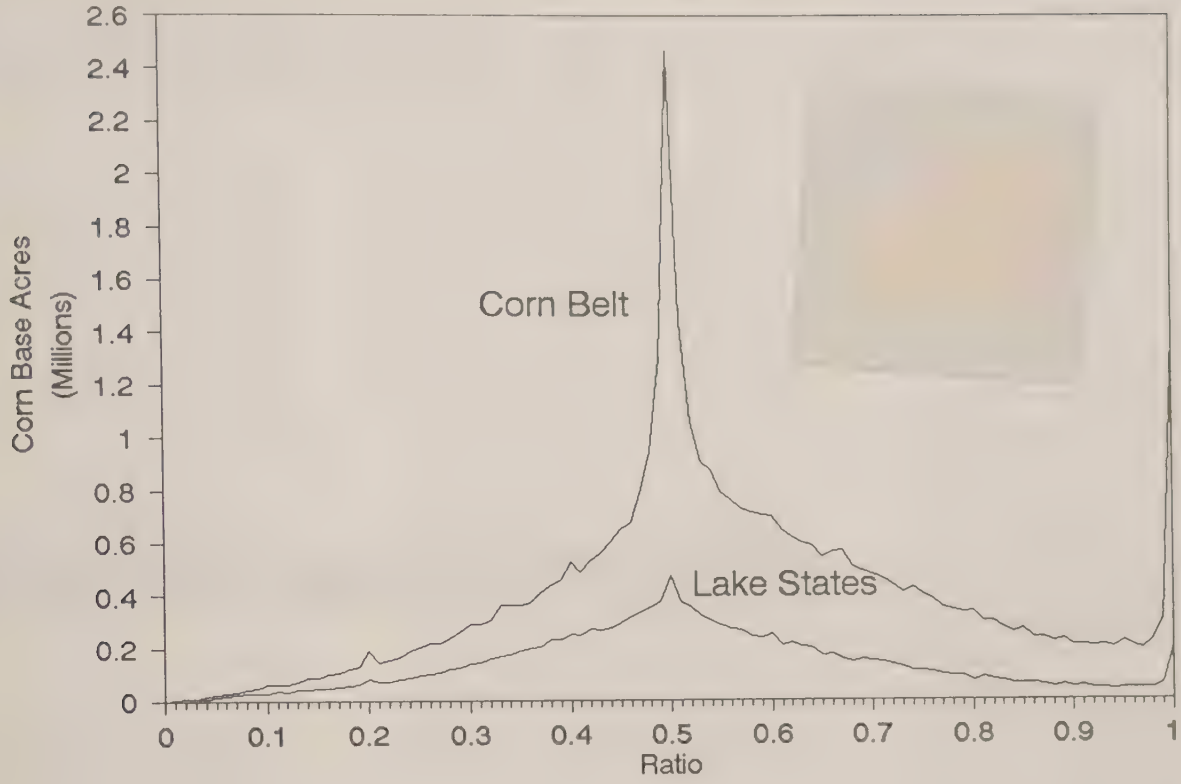
To estimate the potential constraint of the corn program, the ratio of corn base acreage divided by the tillable cropland was calculated for each record at the Agricultural Conservation and Stabilization Service (ASCS) in 1988 for the Corn Belt and Lake States (Figure 2). A ratio of 1 indicates that all cropland is enrolled in the commodity program. A ratio of 0 indicates no corn base acreage. The ratio should not be construed to represent an actual rotation. It is only an attempt to measure the potential constraint that commodity programs place on rotations. For example, even with 10 corn base acres out of 1000 tillable cropland acres, monoculture may be practiced on the 10 corn base acres. However, 990 acres remain available for a rotation. If monoculture is practiced on these 10 acres, it is not because the commodity programs constrained the 10 acres to monoculture. The discussion assumes that cropland is homogeneous on a farm, that is, all land is equally suitable for all crops; this assumption is relaxed later.

The distribution of the base acres rat in Figure 2 has sharp spikes at .5 and At a ratio of 1, only the set-aside acr could be rotated, and monoculture co must be practiced given full participatio in the corn program. Roughly 1.6 mi lion corn base acres fall into this categor in the Corn Belt and Lake States. Fo these "fully leveraged" 1.6 million co base acres, the commodity program pay ment represented approximately 56 pe cent of gross crop income in 1987, 3 percent in 1988, and an estimated 20 pe cent for 1989/1990.

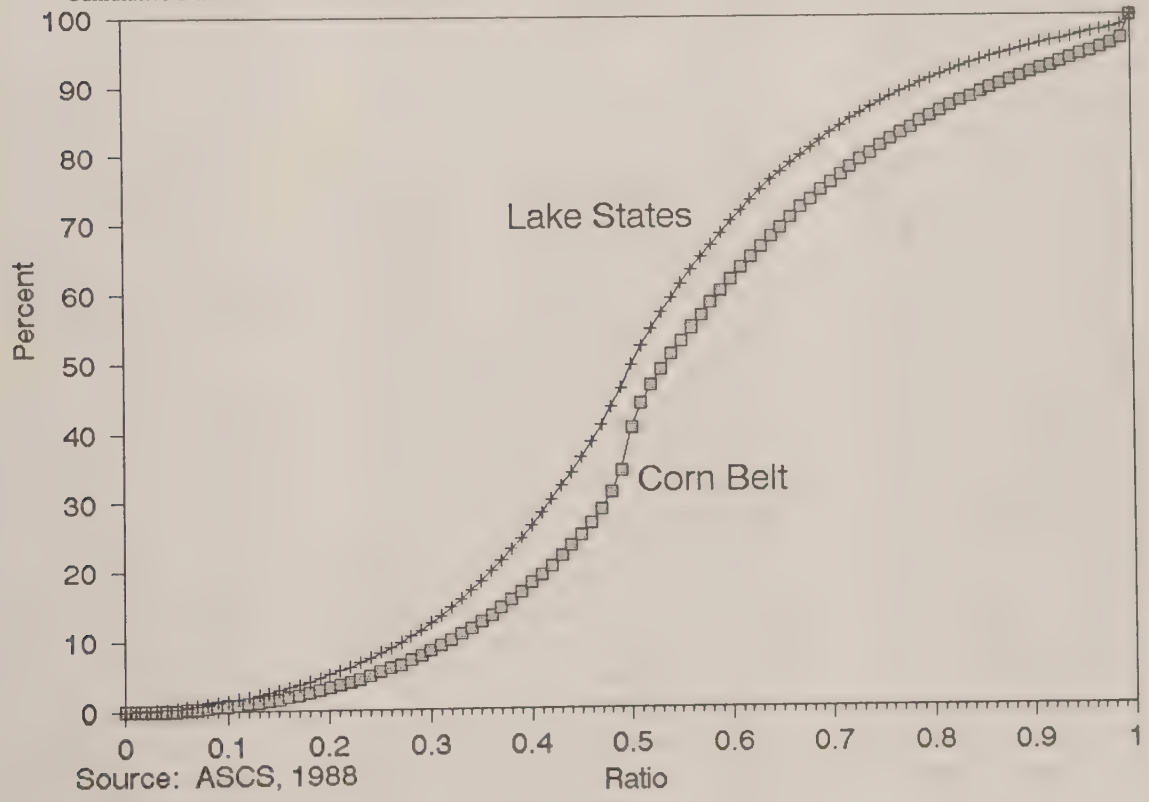
The spike at a ratio of .5 results fro a pervasive corn-soybean (c-b) rotatio in the Corn Belt and Lake States. Ap proximately 44 percent of the corn bas in both the Corn Belt and the Lake State is found between a ratio of .4 and .6 Comparisons with Daberkow and Gi (1989) support the likelihood that thi land is in a c-b rotation. With 50 percen of total farm cropland enrolled in th corn program, a four-year corn-corn oats-alfalfa (c-c-o-a) rotation, whic would lower chemical use, would still b allowed under the program. Yet, ac cording to Daberkow and Gill (1989), o the corn planted in the Corn Belt an Lake States, less than 5 percent followe alfalfa and over 50 percent followed soy beans. Clearly, these cropping choice have more to do with relative returns to c-b rotation versus a diversified rotatio such as c-c-o-a than they do with rota tion constraints from corn program par ticipation.

The distribution shows a wide rang of enrollment levels in the corn progra in the Corn Belt and Lake States. Man acres are not constrained to monocultur corn because of corn program participa tion. Relaxing the assumption of homo geneous land quality will result in larger program constraint on mor farms. Very few farms have consistentl high quality land distributed across thei farm, and poorer land may not b planted to the crop with the highest re turns. Lower yielding tillable croplan will constrain the amount of croplan available for rotation and result in greater rotation constraint from th commodity programs. Particularly whe payments are based on current yield such as before 1986, a greater incentiv

Figure 2. Distribution of Corn Base Acres as a Ratio of Tillable Cropland in 1988.




Cumulative Distribution of Corn Base Acres as a Ratio of Tillable Cropland, 1988




Source: ASCS, 1988

exists to keep the farm's best land in corn to maintain or increase program yields. With the 1986 freeze on yields on which payments are based, this incentive has diminished. No information exists about land quality. How much of an underestimation from the data results is unclear. Roughly 20 percent continuous corn is planted in the Corn Belt and Lake States,

according to Daberkow and Gill (1989). This would represent approximately all acres above a ratio of .7 in the Lake States and .76 in the Corn Belt in Figure 2.

## Implications for research

There is little doubt that commodity programs influence and constrain the decision to rotate: the data from ASCS indicate potential rotation constraint for a minimum of 1.6 million acres that must be in a continuous corn rotation when participating in the corn program. However, the data also suggest that many acres could have been planted in a diversified rotation at 1988 enrollment and participation levels. Why is the land where the diversified rotation option is available not following such a rotation? Many other economic, agronomic, and institutional variables affect rotation decisions. Fleming (1987) outlines several from the current property rights structure affecting the environment to a lack of adequate information about low-input technology. Dabbert and Madden (1986) define a series of transition costs and issues, including commodity programs. Others include economies of scale in conventional rotations from producing a large quantity of few outputs, the need to maintain adequate cash flow, and agronomic limitations such as weather and soil.

Changes may be necessary in the commodity programs to remove potential constraints that exist with the support programs for some acres. But any changes that just eliminate current programs will not be sufficient for widespread adoption of sustainable rotations. Furthermore, to make better informed policy decisions, we need additional research on the extent of commodity program influence on the decision to rotate, the extent of long-term rotation practices nationally, the long-term value of base acreage to a producer, and the role of the commodity programs during the transition to more diverse rotations.

**Acknowledgments.** Any opinions and errors expressed in this commentary are solely attributable to the author. I would like to thank Margot Anderson, Stan Daberkow, and the editors for their review and advice.

### References

1. Dabbert, S., and P. Madden. 1986. The transition to organic agriculture: A multi-year simulation model of a Pennsylvania farm. American Journal of Alternative Agriculture 1(3):99-107.
2. Daberkow, S., and M. Gill. 1989. Common crop rotations among major field crops. Agricultural Resources: Inputs Situation and Outlook. Resources and Technology Division, Economic Research Service, U.S. Department of Agriculture, AR-15:34-40.
3. Dobbs, T., M. G. Leddy, and J. D. Smolik. 1988. Factors influencing the economic potential for alternative farming systems: Case analyses in South Dakota. American Journal of Alternative Agriculture 3(1):26-34.
4. Fleming, M. 1987. Agricultural chemicals in ground water: Preventing contamination by removing barriers against low-input farm management. American Journal of Alternati Agriculture 2(3):124-130.
5. Goldstein, W., and D. L. Young. 1987. An agr nomic and economic comparison of a conve tional and low-input cropping system in the P louse. American Journal of Alternati Agriculture 2(2):51-56.
6. Heady, E. 1948. The economics of rotatio with farm and production policy applicatio Journal of Farm Economics 30(4):645-664.
7. National Research Council. Committee on t Role of Alternative Farming Methods in Mo ern Production Agriculture. 1989. Alternati Agriculture. National Academy Press, Was ington, DC.
8. Power, J. 1987. Legumes: Their potential r in agricultural production. American Journal Alternative Agriculture 2(2):69-73.

## INSTITUTE NEWS

### Mrs. Jean Wallace Douglas named Safe Food Trailblazer

Mrs. Jean Wallace Douglas, former President and Honorary President for Life of the Institute for Alternative Agriculture; Senator Patrick Leahy, Chairman of the Senate Agriculture Committee; and Dr. Fred Kirschenmann, a large-scale organic farmer in North Dakota, were among those named Safe Food Trailblazers last month by the Center for Science in the Public Interest (CSPI), a national health and nutrition advocacy organization in Washington, DC. Mrs. Douglas was cited as "the first major U.S. funder to recognize and understand the importance and relevance of alternative agriculture." Leahy and Kirschenmann, who are members of IAA's President's Council, were praised, respectively, for leadership on national organic food standards and sustainable agriculture legislation and for demonstrating the "economic viability of organic farming."

Other awardees included: Rep. Peter DeFazio (for leading the House floor fight on national organic standards); "Buddy" Maedgen, Jr. (for his efforts to overturn a Food and Drug Administration ban on use of beneficial insects to control pests in stored grain); Sunset Foods (for leadership in consumer edu cation information); Jayne MacLea (for leadership in creating the Alterna tive Farming Systems Informatio Center at the USDA's National Ag ricultural Library); Lynn Coody (fo developing ways to evaluate organi agriculture inputs); and the Wisconsi Rural Development Center (for ob taining state funding for the new Cen ter for Integrated Agricultural System at the University of Wisconsin).

### Institute announces Visiting Scholar Program

Starting this year, the Institute wil offer three- to six-month scholarship to professionals in universities, govern ment, and the private sector to explor issues related to alternative and sus tainable agriculture. Eligible project may deal with national or state policie affecting adoption of sustainable agri culture, conceptual issues, sustainabl agriculture curricula for schools an colleges, international dimensions o agricultural sustainability, or institu tional change and alternative agricul ture. Applications are due March 1 1991. Interested persons should con tact Neill Schaller, Associate Directo for details and instructions on how t apply, (301) 441-8777.

**The Ecology of Intercropping.** 1989. By John Vandermeer. Cambridge University Press, New York, New York. 237 pp. $39.50, cloth.

Intercroppings are complex agricultural production systems that have an ancient lineage and that are frequently tied in with local cultural and social values. Widespread study of the ecology of intercropping is relatively new, even though, as the author points out, intercropping is the usual way for producing the planet's food. Ecological interactions even in monoculture production systems can be staggering, and for some people the even greater complexities of an intercropped production system dissuade study. Still, there is a rich literature of empirical works, much of which deals with descriptive natural history or measurements of land equivalent ratios. Most of this literature is scattered in various disciplines, and much of it has not been published in U.S. ecological or agricultural journals. Until this book, conceptual models tying theories of population and community ecology to interactions at the agroecosystem level were even more scarce and scattered than results of empirical field studies. *The Ecology of Intercropping* provides a much-needed starting point for intellectual discussions across disciplinary biases.

The book is masterfully conceived and is worthy of inclusion on the shelf of every ecologist and agricultural researcher. It is more akin to an essay, as it is a personal perspective on selective topics in the ecology of intercropping. Vandermeer presents a variety of approaches and models, from the abstract general analytical model to the specific engineering model. This results in a tightly knit discussion of plant-plant competition and mutualism based on a large amount of recent work, much of which was published between 1982-1987.

The book is organized into 12 chapters. The first is an introduction that defines terms such as intercropping, multicropping, and sequential cropping, and that discusses the major theme of the book: the organism-environment interaction. The two significant ecological principles that emerge are the competitive production principle and facilitation. Chapter 2 presents the problems of comparing intercrop to monoculture performance, although Vandermeer never discusses why we should want to measure such differences. Despite this, Vandermeer deserves credit for his beautifully done graphical approach to explaining yield interactions between two crops. The next two chapters introduce the main concepts of the book. The competitive production principle is that, if two crop species share the same resource requirements but compete with each other only weakly, they can exist together with yields that are acceptable for an agricultural production system. Facilitation is the enhancement of the environment of one species by another. Chapters 5 and 6 expand on these concepts by giving examples of both observed and theoretical mechanisms that account for these two categories of intercrop interactions. The next three chapters outline specific topics in the ecology of intercropping including perennials, weeds, and risk and stability.

Chapters 10 and 11, which I found to be the most interesting and challenging, should attract the attention of the applied ecologist. They are entitled "Planning Intercrops - A Phenomenological Approach" and "A Mechanistic Approach." Both discuss the author's attempts to develop intercropping systems based upon an understanding of the theories laid out previously. Each chapter takes a different approach to modeling an agroecosystem. The "phenomenological" approach concentrates on the quantified functional relationships among interacting components in the system and the mechanisms underlying these responses. Vandermeer gives a clear, step-by-step presentation of a nonlinear model of competition between two crop plants that is used to develop an optimal intercrop planting design. Field data were used to evaluate the model; when it appeared that the model did not adequately describe a tomato-soybean system in Michigan, another approach (a computer intensive linear method) was developed. The general performance of the second model is then discussed in light of validation field data.

The "mechanistic" approach of Chapter 11 is more specific to the system under study and utilizes knowledge of the mechanisms or processes affecting two specific species. Two good examples are discussed: optimal design of trap crops for insect herbivore control, and optimal design for weed control based upon critical weed-free planting dates. Unfortunately, none of these models involved parameterization or comparison with any empirical data sets, which left me disappointed.

The last chapter, "Critical Research Directions for the Future," is actually a potpourri of topics that the author has not had the opportunity to discuss in earlier chapters. These range from dynamic plant growth models to mechanization in intercropping. Because this is a first cut at formulating a theory of intercropping ecology, *all* the topics mentioned in the book are critical research directions.

A few topics in this book could have used some more discussion. One example occurs in Chapter 11 under the subheading "Pest and Natural Enemy Dynamics." The author mentions that intercrops frequently suffer less damage from pests than monocultures but does not adequately explain why. He mentions the premise that movement within the crop (trivial movement) is

the key factor to study and from there introduces a simple 2-dimensional diffusion model. However, he then states that the diffusion approach should be abandoned, since the situation often is too dynamic to be described by movement alone. Therefore, other factors must be considered, such as plant and insect phenology and population growth rates. Readers who are not well versed in pest-plant interactions will not appreciate this point without additional background discussion. Two linked simultaneous differential equations are presented as the next possible approach, but in the following paragraph Vandermeer states that models have not yet been developed for the complexities operating in a pest/natural enemy/intercrop system. While this not very satisfying conclusion may be true in general, it is far from true for a systems engineering approach at the level of the specific agroecosystem. The reader is left with little to go on, since only a few references are given. It would have been better to discuss the results of some of the many empirical studies on pest-plant interactions, thereby adding depth to the thin conceptual models presented.

Vandermeer is a lucid and very interesting writer, and on occasions I found him quite humorous as well. The book is written in a careful and concise style and appears to have been thoroughly reviewed and proofread. It is not necessary that the reader be well versed in theoretical ecology to read *The Ecology of Intercropping*. However, readers who do have this background will understand better the author's application of many of the conceptual models of theoretical ecology to the intercropping situation. For those who don't but who are willing to put in the extra work, Vandermeer has provided appropriate citations for the relevant ecological principles. Nor is a background beyond first-year calculus required, even though the book has a firm mathematical basis. Most ideas are explained masterfully with the help of tables and narrative examples from empirical studies and clear graphics. Vandermeer makes particularly effective use of graphics in constructing from Levins' concept of fitness sets a framework (yield sets) for analyzing intercrop advantage.

This book will be an invaluable aid to the field researcher planning and analyzing data on ecological interactions in intercropped production systems. It would make a very good text for portions of a graduate course in agroecology (I'll be using it in mine). I recommend it to academics interested in all aspects of agroecology, not just intercropping.--*Frank Drummond, Department of Entomology, University of Maine, Orono, ME.*

**Conservation Farming on Steep Lands.** 1988. Edited by W. C. Moldenhauer and N. W. Hudson. Soil and Water Conservation Society, Ankeny, Iowa. 296 pp. $25, cloth.

This book originated in a March 1987 workshop in San Juan, Puerto Rico, entitled "Soil and Water Conservation on Steep Lands." The fact that the workshop was sponsored by the United States Soil Conservation Service, the United States Agency for International Development (USAID), and the World Resources Institute speaks well for the professional stature of the workshop participants listed at the end. An index with useful key words, such as African conservation failures, runoff water harvesting, infiltration and crop residues, and universal soil loss equation, is unusual for a workshop proceedings and enhances its usefulness as a reference for both academics and field workers.

Although a total of 41 presentations were given during the workshop, the book contains only 32 papers by separate authors. These have been edited and arranged according to specific themes: the problem of soil degradation on steep lands; social and economic ramifications; principles and practices of conservation; and case studies of natural resource management projects from around the world. The chapters range in length from just over one page to sixteen pages, suggesting either severe editing of specific presentations or a wide variation in the amount of information available on particular subthemes.

The titles of the first two chapters, "Tilting at Windmills or Fighting Real Battles" and "Conserving Soil by Stealth," will surely capture the attention of most readers. These introductory chapters lead to more technical presentations on field experiences in the implementation of conservation practices. Additional attention, although limited, is given to project planning, incentives for farmers, training needs, and monitoring and evaluation systems.

Lessons are gleaned from the experiences of the Food and Agriculture Organization in Jordan, Ethiopia, and Lesotho. Among these are the need for long-term government support, land tenure systems that favor long-term management rights, and the need for visible short-term benefits from applying conservation methods. In contrast, the show-and-tell chapters on the international activities of USAID and the Soil Conservation Service lack substance.

A reader who is new to the subject may find the introductory chapters interesting. However, to the field practitioner, the essence of the book begins with the detailed descriptions of case studies of projects and field practices. Although individual chapters in this section are concise, the discussion covers many topics: methods for estimating the rate of soil erosion; data collection and analysis; survey questionnaires to determine farmer perceptions of erosion; and economic assessment of soil conservation benefits. Examples are drawn from 11 case studies from Southeast Asia, Africa, Australia, and Latin America.

The workshop sought to compare successful approaches to soil and water conservation and to provide evidence on the magnitude of the soil erosion problem worldwide. A recurring theme is the need for a conceptual approach to development that integrates water and soil conservation practices with efforts to expand agricultural production. The authors agree that the success of soil and water conservation activities requires the full cooperation of farmers

and, therefore, should involve a bottom-up planning process. They highlight the many institutional and policy constraints that are frequently encountered in the application of conservation theory to practice. The workshop also produced a companion manual designed to allow field technicians to integrate conservation practices in agricultural production systems.

The importance of stabilizing the productive capacity of natural resources while also increasing food production to meet the demands of a growing population is receiving ever greater attention as discussions focus on the sustainability of world agriculture. With regard to international development, the book puts forth the view that steady, sustained pressure to encourage more effective use of natural resources is preferable to throwing large amounts of money at the problem for a short time. However, along with policy and procedural suggestions, the book outlines many practical techniques that can maintain the productivity of soils that for topographical reasons are especially susceptible to erosion.

The book only has a few small flaws. The short chapter on soil taxonomy seems very incongruous in a section on technical aspects of soil conservation. Also, the liberal use of field examples early in the book makes the 78 pages of case studies in the later sections seem anticlimactic. And while the glossy black book cover may be attractive in the bookstore, it shows fingerprints easily.

Despite these minor shortcomings, the editors deserve credit for condensing a large number of presentations about specific countries into easily digestible segments. The general approaches to conservation and the criteria for project success are well summarized in the last chapter.

The book is aimed primarily at individuals and organizations who design, finance, and implement agricultural development schemes. However, its global perspective also would make it valuable as a reference or textbook in undergraduate courses in agronomy, soils, agroforestry, and natural resource management. Although the chapters often vary widely in technical and geographical focus, the editors did an admirable job of weaving a collection of disparate papers into a unified treatment. The tables, diagrams, and hand-drawn illustrations of conservation structures are well done and easy to understand. The discussion of the principles and practices of soil conservation in agricultural development is thorough and is substantiated with clear examples from realistic situations. As an up-to-date reference for soil and water conservation, this book is certainly a welcome addition to my bookshelf.--*Robert E. Hudgens, Senior Program Officer, Sustainable Agricultural Systems, Winrock International Institute for Agricultural Development, Morrilton, AR.*

**Ecological Approach to Pest Management.** 1988. By David J. Horn. The Guilford Press, New York and London. xiii+285pp., index. $35, paper.

This book attempts to integrate ecological principles and insect pest management strategies into one coherent, workable management philosophy. The author accomplishes this by presenting both theoretical and practical concepts needed to better understand the complex interactions in pest management.

The introductory chapter gives a concise overview of the beginning of pest management or applied entomology in the United States and describes the many professional organizations and government agencies that have evolved from these beginnings. Two chapters deal with the practical considerations of economic decisions and sampling theories and give clear definitions of two often confusing terms: economic injury level and economic threshold. Many important concepts in insect population biology are also reviewed in these two chapters. There are many useful, instructive, and up-to-date examples in these chapters; but some readers may find the mathematics a bit difficult to follow.

A short chapter on plant-insect interactions does a good job in examining all the major topics relevant to how plants affect insects, such as plant nutrition, chemical and physical defenses, multi-level trophic interactions, plant density, and plant texture. However, there is only a cursory discussion of insect effects on plants. The major families of insecticides, as well as narrow spectrum or biorational insecticides (i.e., bacteria, viruses, nematodes, insect growth regulators), are reviewed in three chapters that cover both chemical and biocontrol methods. The fact that one chapter is on biocontrol may reflect the present state of economic entomology. That is, while biocontrol is recognized as useful in a few isolated cases, it is no longer considered a major area of research for integrated pest management programs, although Horn points out that when time, effort, and funds are put into it, it often is successful. The book offers only a token treatment of the very important topics of plant resistance and cultural control. Much more should have been said on these important ways of altering agroecosystems to reduce insect, weed, and plant pathogen pests without resorting to expensive and environmentally damaging chemical inputs.

The book is easy to read, with the author avoiding the all-too-common practice of using highly specialized jargon excessively. Although it is intended for economic entomologists at the undergraduate or graduate level, readers with an interest in agricultural pest management will find the book very informative and easy to follow in general, with abundant practical and illustrative examples to help explain difficult or confusing topics. The chapter on population sampling illustrates this point, combining theoretical concepts with practical considerations, and discussing the strengths and weaknesses of different sampling techniques. However, in some of the early chapters, an understanding of statistics would be helpful but not essential. Many graphs and tables are used effectively to help elucidate concepts brought up in the text, and the 32-page list of references is very up to date and thorough.

One problem is the title. The book should more appropriately be entitled "Ecological Approach to *Insect* Pest Management." There is little information about other pests, such as nematodes, weeds, plant diseases and their management, nor is there information about how abiotic conditions, such as soil fertility, weather, and soil chemistry influence insects, plants, or insect-plant interactions. This may demonstrate the bias of many IPM programs, which actually are integrated *insect* pest management programs. To change this, more research is needed that examines the field as an entire agroecosystem, not as individual, noninteracting parts that each researcher examines separately. This book, however, does unite many of the more important and relevant principles of insect ecology with the practical aspects of modern IPM programs.

The book gives a balanced treatment of both theoretical and practical considerations, with many up-to-date examples. The author discusses the idea that we can no longer afford a total reliance on chemical controls in our agricultural systems without severe environmental or economic problems, but he does not advocate elimination of pesticides. Rather, Horn advocates that we use them judiciously, in accordance with sound economic and ecological principles. In summary, I think this book will be a valuable resource for both farmers and students.--*Gerald E. Brust, Post-Doc, Department of Entomology, North Carolina State University, Raleigh, NC.*

**Sustainable Agricultural Systems.** 1990. Edited by Clive A. Edwards, Rattan Lal, Patrick Madden, Robert H. Miller, and Gar House. Soil and Water Conservation Society, Ankeny, Iowa. 696 pp. $40.00, cloth.

I approached this book with high expectations. It is the largest and most comprehensive book on sustainable agriculture to date (yet its price is very reasonable by today's standards). A quick glance at the table of contents told me that it addresses all the major areas of agricultural sustainability: soil fertility, weed and insect pest control, soil microbiology, rotations, agroecosystem diversity, plant genetics, pasture management, research policy, and so forth. Moreover, it covers not only the U.S. but also many other parts of the world, including China, India, Africa, Latin America, and Western Europe. Many of its 40 chapters are by leading figures in the field, and its editors are very prominent as well.

Unfortunately, my expectations were not fulfilled: the book contains far more factual errors than the reader should be expected to put up with. I was willing to overlook the first few, since everyone makes mistakes occasionally. But they began piling up so rapidly that it was hard to concentrate on the book itself--I found I mainly was counting the errors. The final tally was 24, all of which I discovered just from everyday knowledge or from inconsistencies within the book itself, without going to other sources.

Here are some of them, each of which comes from a different chapter:

--The world's population of 5.1 billion is said to be growing at 2.1 percent annually (p. 203). This is births minus deaths, yet the reported birth rate, 230,000 per day, amounts to only 1.6 percent per year.

--A table of the different regions of Africa gives their land areas in units of "10 bha," with the growing period in one of them reported as 7,270 days (p. 328).

--"About 72 percent of Peru's national rice production...was harvested on the coast, with the remaining 38 percent in the Amazon" (p. 400).

--"Each of [the USDA-LISA program's] four regions--Northeast, South, North, Central, and West..." (p. 457).

--"Preferences for low-input disease control were correlated with preferences for low-input disease control ($r=0.23$)" (p. 529).

--The equation of a positively-sloping straight line relationship between productivity and time is stated as $Y = -.6109T^{1.2038}$ (p. 565).

--"The collapse of the Mayan civilization in South America..." (p. 569).

--"Feed grains--corn and wheat, primarily..." (p. 604).

--A chart comparing various organisms shows bacteria and fungi in the size range of a few meters (p. 639).

And so on. Similar problems plague the references. Entirely too often authors' names are misspelled, journal titles are garbled, dates are inconsistent between text and reference list, and works cited in the text are omitted from the reference list. A single sentence in the chapter by the senior editor (p. 251) has the wrong date in 5 of its 6 citations. A curious aberration, which by itself is of no great consequence but which to me seems symptomatic of the editorial approach taken throughout, is that in a chapter from Germany, no one thought to substitute decimal points for the commas customarily used in Europe. Thus an entire table (p. 281) has numbers like −36,19%. But that table fared better than the one that was omitted entirely and had to be supplied by a mailed insert.

Is this just quibbling? After all, most of these mistakes are not catastrophic, and an occasional mistake is inevitable, especially in a book of this size. Might the book not be considered valuable despite these problems?

I don't think so. When I read any highly technical book, the accuracy of the facts that I know about is how I judge the accuracy of the much larger number of facts that I don't know about. That is the only way I can know how much confidence I should have in the book as a whole. Given the large number of errors I found without even going to other sources, I would consider it imprudent to cite anything from this book that I didn't first corroborate independently. But that task shouldn't fall to the reader.

This book has many things going for it. Unfortunately, a reasonable standard of accuracy is a prerequisite for a book to serve a legitimate professional purpose. It is too bad that here the governing principle seems to be "Let the reader beware."--*William Lockeretz, Research Associate Professor, School of Nutrition, Tufts University, Medford, MA.*

### *Education for a sustainable agriculture*

I very much enjoyed Volume 4, Nos. 3 and 4, of the *AJAA*. Under "Opinion" Dr. Charles A. Francis suggests ten ways to sustain agriculture and development. All ten of his suggestions are important and would help to achieve the sustainable agriculture and development that we seek. Rather than add an eleventh, ten seems so round, I would expand his third suggestion to include a larger concern for our general approach to farmer education for sustainable agriculture and development. Dr. Francis' third suggestion, "Evolve from 'product use' to 'problem solving process' mentality," is crucial. This suggestion involves several issues that require being dealt with and resolved before education for sustainable agriculture and development can take place.

**Farmers are not targets.** We often talk of those we work with as target audiences. What do we target them for? Education? What kind of education is shot at a target? "Product use" education. "Product use" education is not concerned only with information about brand name materials, it also includes the kind of education or information we at land grants are apt to provide. This "product use" education is characterized by short-term answers developed from a process controlled by the land grant system and targeted at farmers. A result of "product use" education is the increased dependency of the target on the provider of education for continued support. "What herbicide can I spray to kill the weeds?" is an example of the dependency created by our traditional approach to education for farmers. We need to correct that approach to that which would break any dependency relationship. Sustainable agriculture and development is carried out by independent empowered farmers.

**Time horizon.** We often treat education for farmers as if it has to be done today. We shy away from processes that might take a year or two. "Problem solving" education takes time, is not accomplished by one workshop or farm visit, and provides a format for all additional education. Providing a direct answer to a question such as "What herbicide can I spray to kill the weeds?" evades responsible education. Working with the farmer to discover the kinds and numbers of weeds existing in his/her field during various stages of crop growth and their interactions with the crop takes longer, but the farmer begins to discover a method for analysis and decision making that carries over into all aspects of his/her farm operation.

**Who is in control of education?** When farmers can discover and learn on their own, what will be the function of Extension? This is a question that lurks in the dark regions of our minds, but we hesitate to articulate it, much less answer it. Education for sustainable agriculture and development means education that will empower farmers to be field experts in sustainable agriculture and decision making. Extension and research have an inexhaustible role in working with farmers to achieve that goal.

**Learners as teachers.** Education for sustainable agriculture and development requires an approach that considers learners as teachers and teachers as learners. We all have something to contribute to the educational process, both as learners and as teachers. Sustainable education involves all participants in both roles. An indirect benefit of such an approach is that processes are developed that encourage "learners as teachers," and these processes will be used by learners when they are asked by neighbors to teach them about sustainable agriculture.

**Learning materials as found materials.** Education for sustainable agriculture and development does not need to rely on centrally produced learning materials. What happens with a crop in the field is the focus of sustainable education. This can be learned best in the field, not in the classroom. Slides, movies, television, and written materials are all substitutes for firsthand field experience. Farmers have this, and working with them in their fields helps them to better see the relationships that exist in their fields. Classroom materials are a substitute that creates a dependency relationship--learners and teachers come to believe that education can take place only with the help of learning materials. Learning materials should be recognized as substitutes for experience and be given their proper role of supporting education, not leading education.

**Farmers as researchers.** Farmers can and should conduct their own research. Extension should be prepared to help farmers figure out how to conduct this research and then help farmers communicate their research to each other. University researchers have their role in discovering new knowledge. Farmers, too, have a role in discovering what is going on in their fields and developing solutions to help them manage their fields and farms.

The above are a few quick thoughts concerning "sustainable" education. We, too, often neglect thinking about educational processes as we set out to work with farmers. The educational process we use determines the results we will achieve. If sustainable agriculture and development are our goal, then let us use those educational processes that will contribute to that goal.

*John Pontius*
*Extension Specialist*
*Agriculture*
*University of Massachusetts*
*Department of Resource*
*Economics, Draper Hall*
*Amherst, MA 01003*

*OPINION--Continued from page 98*

that it can be applied *as needed*. NCWC can capitalize on favorable conditions to reduce costs, work, and management. For example, if rainfall is delayed after planting, conditions have permitted me to complete effective weed control with one rotary hoeing and one cultivation. In contrast, CWC systems are committed to the cost of herbicide before post-planting conditions are known. CWC has no flexibility to capitalize on cost-saving opportunities.

Crusting is one problem after planting. For CWC systems, breaking a crust with a rotary hoe is a wholly additional cost. For NCWC systems, the crust-breaking tillage can be an additional benefit of the first scheduled rotary hoeing, so that its cost can be disregarded.

Another threat is early crop failure from many causes: heavy rain, hail, lost weed control, or plant diseases. Crop failure may create two problems peculiar to CWC. The first is the inflexibility of herbicides discussed above. For NCWC, crop failure means that some weed control costs can be avoided. The other potential problem after crop failure is herbicide incompatibility between the lost crop and the replacement crop. Suppose that a field of milo is destroyed by hail on approximately June 15. The most obvious planting option available would be soybeans. There is a good possibility that soybeans would be incompatible with the milo herbicide. Even if the damaged crop is replaced with the same crop, it is difficult to determine whether enough of the original herbicide remains or whether a second application would be too much.

Two additional notorious problems of CWC are herbicide drift and weed resistance to herbicides. Herbicide drift can dan age the applicator's other crops as well as those of neighbor NCWC has no potential to harm other crops. The fast deve oping problem of weed resistance to herbicides continues t include more kinds of weeds and expand to more areas of th United States, another problem unique to CWC systems.

**Conclusion**

CWC generates problems at every stage of the growing sea son. Problems peculiar to this system include crop rotatio restrictions, greater machinery costs, possibly extra pre-plan tillage, a small margin for error in application, herbicide stressed crops, application demands at the busy planting time inflexibility in coping with various crop conditions after plan ing, herbicide drift, and weed resistance to herbicides.

NCWC is beset with its own significant challenges. Concern include informed diversified crop rotation, lengthened plantin dates to coordinate the workload of mechanical weed contro and meticulous timing and application of mechanical weed con trol. Further, extremely wet growing seasons challenge NCW and reduce the farmer's options. It is important to note, how ever, that these special concerns are surmounted by learnin new skills and better management, not by additional capita outlays.

It is not clear how to tally which system "wins" this competi tion. I have described how chemical weed control--advertise as convenient in making weed control easier--causes numerou complications, inefficiencies, and unresolvable problems, whic do not plague chemical free weed control approaches with ro crops.

## UPCOMING EVENTS

**March 11-14. International Conference on Agriculture and the Environment** at Columbus, Ohio. Organized by The Ohio State University. Environmental, ecological, economic, and social issues are focus. For more information, call (614) 292-8209.

**March 15-17.** Food safety and pesticide poisoning are key topics at the **Pesticide Forum,** a 10th anniversary event sponsored by the National Coalition Against the Misuse of Pesticides (NCAMP). Information is available from NCAMP at 701 E Street, SE, Washington, DC 20004, (202) 543-5450.

**March 18-20. Farming for the Future: In-Service Training in Organic and Sustainable Agriculture,** to be held on the Cornell University Campus, Ithaca, New York. Sponsored by the Northeast Organic and Sustainable Farmers Network. Open to extension, USDA, and other agriculture professionals. For registration information, contact Judy Green, Cornell Farming Alternatives Program, (607) 255-9832.

**March 21-22.** A symposium on **Prospects for Lupins in North America.** Ramada Hotel, St. Paul, Minnesota. Sponsored by Minnesota Extension Service. For information, call Extension Special Programs at (800) 367-5363 or (612) 625-2722.

**April 9-11. Use of Cover Crops for Erosion Control** is focus of a Soil and Water Conservation Society Spring Conference at Jackson, Tennessee. Contact the Society at 7515 Northeast Ankeny Road, Ankeny, IA 50021, (515) 289-2331.

### LETTERS TO THE EDITOR INVITED

The AJAA welcomes letters, short or long, commenting on articles in this journal or sharing ideas likely to be of interest to other AJAA readers. Since our space is limited, we do reserve the right not to publish all letters or, at times, to publish only excerpts from them. To take part in this exchange of ideas, write to: Editor, AJAA, 9200 Edmonston Road, Suite 117, Greenbelt, MD 20770.

# uide for authors



The American Journal of Alternative Agriculture (AJAA) blishes original research on biological, physical, or social ence aspects of alternative agriculture. We particularly welme multi-disciplinary studies, but papers from a specific cipline also are invited. However, since AJAA readership much broader than for a single-discipline journal, highly ecialized terminology should be explained or avoided. The nificance of a statement, or the reasoning behind a conision, may have to be spelled out more than in a more ecialized journal. See Vol. 5, No. 1, pp 2 & 3, for an planation of the various categories of articles.

### nits

Research papers should use the International (SI, or metric) stem throughout. Occasional use of common unit equivants in parentheses is permitted, mainly for relatively exotic units.

### tle page

The title page should give the following information (all sh left): 1) title of the paper; 2) names of authors; 3) afiation and office address of authors, and 4) acknowledgeents, if any. See examples in this issue of AJAA.

### bstract

The abstract should be 200 to 400 words suitable for readers om a broad range of disciplines. It should avoid highlyecialized terminology that might be appropriate for a single scipline journal. Take particular care that the significance the work is made clear, even to readers from a different eld.

### ey words

Provide subject matter key words suitable for use in scienic indexing.

### eference list

When citing material that has been covered in more than ne format, such as the typescript of a conference presentation d a journal article, preference should be given to the version at is most readily available, and that is likely to remain so. enerally this means standard publication channels, such as ooks, journals, and regular government report series. Unpubshed or informally-published material should be cited only hen no alternative form exists.

References should be listed in alphabetical order by author's ame, and by year for a particular author (with letters after e year if needed). If a sole author is also the lead author of apers with multiple authors, use the following order: single uthor (by year); two authors (alphabetically by second author's name); three or more authors (by year). Repeat the author's name for each reference. Use initials only for first and middle names. Give the names of all authors in the reference; never use "et al."

Use full names of journals, institutions, conferences, etc., except for extremely familiar abbreviations like "Dept." Remember that an abbreviation familiar to you may not be familiar to readers outside your field. If in doubt, write it out.

The reference list uses no quotation marks, italics, boldface, or underlining. Only the names of books and periodicals are in initial capitals. Names of papers, book chapters, pamphlets, and bulletins are not capitalized. Page numbers are written out in full (e.g., 1108-1123, not 1108-23). The volume is given if page numbers begin at 1 for each issue.

### Citing references

Cite references in the text by last name and year, with chapter or page numbers if the reference is a book or lengthy report. For two authors, give both names. Do not use "et al." unless there are at least three authors.

### Footnotes

AJAA does not use bibliographic or substantive footnotes. All bibliographic references should be at the end of the text. Instead of substantive footnotes, include the material in the main text or consider eliminating it.

### Manuscript preparation

The entire manuscript, including abstract and references, should be typed on one side of standard-size paper, double spaced, with margins of at least one inch all around. Starting with the title page, label all pages in the upper righthand corner with the lead author's last name and the page number. Do not use hyphens unless the hyphen is part of the word.

Follow the section headings style used in this AJAA issue. All headings are flush left, with no underlining or italics.

Tables should fit on one page, be numbered consecutively with Arabic numerals, and be on a separate sheet. Leave extra space to separate columns. Every figure and table should be mentioned at least once in the text.

### Submission of manuscripts

Submit four high-quality copies to Editor, American Journal of Alternative Agriculture, Suite 117, 9200 Edmonston Road, Greenbelt, MD 20770. The cover letter should state that the manuscript is an original contribution that has not been published elsewhere in substantially the same form; that it is not currently under consideration elsewhere, and that permission has been obtained for any copyrighted material used.

# How you can help support the scientific and educational needs of a sustainable agricultural system

A growing number of Americans have become concerned about the long-term sustainability of our food production system. Farmers and agricultural scientists are among those raising questions about the growing dependence of modern farming on nonrenewable resources, the depletion of our resource base through soil erosion, and heavy reliance on chemical fertilizers and pesticides. Continued heavy reliance on farm chemicals is questioned because they have become an expensive production input. Their widespread use also raises questions about human and animal health, food quality and safety, environmental quality, and the continued demise of the family farm.

Low-input alternative farming methods address these economic and environmental challenges. Alternative production systems point the way toward more profits, more individual choice, and long-term sustainability for our food system. More must be done to develop effective ways to make sure research, education, and information sources are readily available to farmers who want to adopt these techniques.

The Institute for Alternative Agriculture needs your help in meeting this challenge. We are a nonprofit tax-exempt research and education organization set up in 1983 to encourage and facilitate the adoption of low cost, resource conserving, and environmentally sound farming methods. We work directly with government agencies, colleges and universities, producer groups, and other institutions that provide research, education and information services to farmers.

The Institute also provides these services:

- *A resource to lawmakers and others who influence agricultural research, education, and information policy*
- *A voice for alternative agriculture in Washington*
- *A sponsor of research and education outreach programs*
- *A national clearinghouse for information on alternative agriculture*
- *A publisher of reliable scientific information on agricultural sustainability*

**If you're interested in helping us, please contact our office at 9200 Edmonston Road, Greenbelt, MD 20770. The phone number is (301) 441-8777.**

INSTITUTE FOR ALTERNATIVE AGRICULTURE, INC.